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MYCOLOGIA

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VOL. XLIX NOVEMBER–DECEMBER, 1957 No. 6

A SURVEY OF THE FUNGI OF FOREST AND CULTIVATED SOILS OF GEORGIA [1]

J. H. MILLER, J. E. GIDDENS AND A. A. FOSTER [2]

(WITH 30 FIGURES)

An attempt has been made to determine the soil-inhabiting fungi of Georgia from soil samples from many different environments. The emphasis has been chiefly on kinds of fungi rather than on numbers. Colony counts were made only of the general groups of bacteria, Actinomycetes and fungi from certain collections in order to obtain the relative proportions of each.

There have apparently been no previous investigations of this type in the Southeastern States. The nearest approach has been that of Abbott (**1**) in Louisiana and Morrow (**39**) and Werkenthin (**67**) in Texas. These studies, however, dealt with soils of a higher pH than is found in most Georgia soils, and only Morrow included forest soils in her studies.

There have been, however, many other such studies in other regions, as those of Jensen (**29**) in New York, Waksman (**60**) in New Jersey, Paine (**42**) in Iowa, Tresner et al. (**58**) in Wisconsin, Bisby et al. (**9, 10**) in Manitoba, Warcup (**64**), Nicholls (**41**) and Stenton (**50**) in

[1] Journal Paper, No. 31, College Experiment Station, University of Georgia, Athens, Georgia.

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the British Islands, Jensen (**30**) in Denmark, Chaudhuri and Sachar (**15**) in India, and Farrow (**22**) in Panama and Costa Rica. These reports have provided lists of fungi occurring under diverse environments.

The Georgia terrain consists of mountains up to 4768 ft. in altitude, a limestone valley, a piedmont plateau of low hills and thin, eroded soil, and a sedimentary coastal plain. Except for the mountain area the winters are mild without deep freezing of the soil, and the summers are usually hot and dry. The average pH is on the acid side, between 5 and 5.6 with the lower for forest soils. Humus decomposition is very rapid. This environment is quite different from that of other areas in which soil-inhabiting fungi have been investigated.

MATERIALS AND METHODS

Soil samples were collected from different parts of Georgia, at different times of the year, and from the most representative soil types both in forest and in cultivation. Most of the samples were composite collections from five sites obtained to a depth of four inches. Some samples for the study of fungus species were also obtained at depths of 2, 6, 12, and 24 inches from several locations by digging a pit and taking samples from the sides. For the study of the general groups, samples were taken at 1, 2, 6, 12, and 24 inch depths.

All determinations were made from Petri dish plates by both direct inoculation (sprinkling small particles of soil on plain agar) and by soil dilutions following the method outlined by Allen (**3**). A dilution of 1 part of soil to 10,000 parts of medium was found most satisfactory, although other ratios were also used.

All permanent culture media contained 0.01% lindane (Newton and Nibley, **40**) for control of mites.

Many kinds of media were used in an attempt to isolate the maximum number of species. For isolation purposes transfers were made to Czapek's agar, especially for *Aspergillus* and *Penicillium* species. For most of the others potato-dextrose agar was used. Yeast extract agar, malt agar or corn meal agar was necessary to induce sporulation in difficult species. Some of the nutrient media tried were as follows.

Rose bengal-streptomycin agar. Martin (**33**), Farrow (**22**).

Rose bengal-streptomycin agar plus macerated filter paper and either pine or hardwood sawdust added.

Rose bengal-streptomycin agar with pieces of cotton or alfalfa stems and leaves sterilized according to Hansen and Snyder (**25**) with propylene oxide.

Czapek's agar. Raper and Thom (**46**).

Hemp seed agar. Farrow (**22**).

Hemp seed agar plus 1 or 5% NaCl.

Carbohydrate media—dextrose, sorbose, lactose, mannose, arabinose, L-xylose, galactose, starch and inulin. One liter of the medium contained 10 gm of one of the above and 5 gm of peptone.

Warcup's medium (**62**).

Thornton's medium (**56**) adjusted to pH 4.2, 5.2, 6.1, 7.0 and 8.4.

Plain water agar—20 gm agar per liter.

Vitamins with corn stalks—thiamin hydrochloride, biotin solution. Farrow (**22**).

Dextrose-peptone agar, 10 gm dextrose, 5 gm peptone per liter and 5, 10, or 20% NaCl added.

Sodium desoxycholate medium. Tatum et al. (**54**). 0.03 gm sodium desoxycholate, 20 gm dextrose, 5 gm peptone and 14 ml of 1% streptomycin per liter.

Apple technique. Campbell (**13**).

All of the above were used in soil dilution plates except of course the apple method. Most of these were discarded after a few trials and rose bengal-streptomycin medium in soil dilution plates with duplicate plates of plain agar and direct inoculation was used for most of the samples.

RESULTS

Use of Various Media. Some of the media used for primary isolation of fungi were more effective than others. The rose bengal-streptomycin agar yielded the greatest number of species. It was especially valuable in limiting colony size and in suppressing bacteria and Actinomycetes. Adding alfalfa or cotton parts sterilized with propylene oxide did not increase the different kinds of fungi isolated.

Czapek's agar was advantageous for immediate determination of *Penicillium* species because of the colors produced, but most of the Phycomycetes except *Cunninghamella* species grew very poorly on it.

Absidia, Cunninghamella and *Rhizopus* species grew well on the hemp seed agar. The addition of 5% NaCl decreased the growth of some *Mucor* species, but produced no other advantage.

None of the carbohydrate media was of especial value in the isolation of additional species. There was some repression of colony growth with sorbitol, especially of *Penicillium* species. Either rose bengal or streptomycin was necessary in the carbohydrate media to suppress bacteria.

The Warcup (62) medium was not superior to the rose bengal medium, and most Phycomycetes grew so luxuriantly on this medium that isolation of other fungi was difficult.

For determining relative numbers of all microorganisms Thornton's medium was superior to others screened. Fungal growth was retarded.

TABLE I

NUMBERS (IN THOUSANDS) OF BACTERIA AND YEASTS, ACTINOMYCETES, AND FUNGI IN CERTAIN GEORGIA SOILS SAMPLED DURING WINTER AND SUMMER (PER GRAM OF DRY SOIL)

Location and soil	pH	Bacteria and yeasts		Actinomycetes		Fungi	
		Winter	Summer	Winter	Summer	Winter	Summer
COASTAL PLAIN							
Dodge County							
Plummer (Forest)	4.5	770	6,000	152	288	294	800
Bleckley County							
Magnolia (Cult.)	5.6	2,982	1,616	810	432	126	288
Norfolk (Cult.)	5.9	810	2,336	668	176	92	144
Norfolk (Forest)	5.2	98	608	76	96	98	416
PIEDMONT PLATEAU							
Clarke County							
Congaree (Cult.)	6.0	320	10,040	460	2,100	30	380
Cecil (Cult. cotton)	6.4	740	4,200	80	1,320	20	140
Cecil (Forest)	5.4	190	2,520	60	320	20	340
Cecil (Cult. Alfalfa)	7.1	160	5,280	380	2,340	20	120
APPALACHIAN MTS.							
Union County							
State (Cult.)	5.2	2,380	8,270	760	574	135	321
Fannin (Cult.)	5.7	770	8,576	130	87	78	525
Fannin (Forest)	5.0	670	2,648	40	0	104	525

Winter Sampling: 1/13/55 for Coastal Plain
12/20/54 for Piedmont
2/15/55 for Mountain soils
Summer Sampling: 6/10/55 for Coastal Plain
5/10/55 for Piedmont
8/20/55 for Mountain soils

Adjusting the pH to various levels was of no particular advantage. Fewer fungi and more bacteria and Actinomycetes occurred as the pH was raised above 7.

Plain water agar with streptomycin was especially useful in isolating species of *Fusarium, Phoma, Thielavia, Curvularia* and *Pythium.*

When using vitamin medium or rose bengal plus filter paper or sawdust no different species were obtained. *Chaetomium* species grew well on the filter paper. The use of dextrose-peptone medium containing NaCl was of interest only in that at the high salt content (20%) *Penicillium, Cladosporium* and *Gliocladium* were the only genera present.

Sodium desoxycholate in the medium retarded colony growth markedly, and so increased the ease of securing pure cultures.

Phytophthora cinnamoni was secured only by the apple technique.

Distribution of Microorganisms in Georgia Soils. The total number of bacteria outnumbered the Actinomycetes or fungi (TABLE I) in Georgia soils. Fungi occurred in greater numbers for the summer sampling than for the winter. The same was true for bacteria in all

TABLE II

EFFECT OF DEPTH OF SOIL ON POPULATION OF MICROORGANISMS IN CERTAIN PIEDMONT SOILS. NUMBERS IN THOUSANDS PER GRAM OF DRY SOIL

Soil depth	Bacteria	Actinomycetes	Fungi	Total micro-organisms
CECIL SOIL—ALFALFA				
0–1 in.	9200	8020	320	17,540
2 in.	5320	2580	300	8,200
6 in.	4200	2440	240	6,720
1 ft.	2820	960	460	4,240
2 ft.	720	120	420	1,200
CECIL SOIL—COTTON				
0–1 in.	3400	1640	520	5,760
2 in.	4820	960	900	6,860
6 in.	2440	1180	160	4,780
1 ft.	740	200	400	1,340
2 ft.	380	200	140	720
CECIL SOIL—FOREST				
0–1 in.	4720	1680	480	7,080
2 in.	3320	1920	140	5,400
6 in.	4860	1440	340	6,640
1 ft.	2260	480	40	3,180
2 ft.	800	180	80	1,060
CONGAREE SOIL—CULT.				
0–1 in.	13,220	2680	620	16,520
2 in.	11,920	7260	240	19,420
6 in.	4,880	2500	220	7,400
1 ft.	2,220	1020	120	3,360
2 ft.	680	120	140	940

Sampled August 9, 1955.

cases except in the Magnolia soil, while for the latter and Norfolk (cultivated and forest), State and Fannin (cultivated and forest), Actinomycetes predominated during the winter.

The number of fungi in proportion to bacteria and Actinomycetes was greater for the forest soils than for the cultivated. Soil pH was lower for the forest soils at each soil area sampled than for the cultivated. There was greater variation in the ratio and in total numbers of microorganisms between soil types within a geographic area than between mountains, piedmont and coastal plain.

TABLE III

SUMMARY OF SPECIES OF FUNGI ISOLATED WITH PERCENT OF PLATES IN WHICH EACH ONE OCCURRED

	Forest		Cult. fields	
	N. Ga.	S. Ga.	N. Ga.	S. Ga.
Nos. plates	348	90	178	141
Nos. samples	15	8	10	12
PHYCOMYCETES	%	%	%	%
Absidia butleri Lendner	.6			
Absidia spinosa Lendner	4.9		3.4	
Choanephora conjuncta Couch	.3			.7
Conidiobolus villosus Martin	.6		.6	1.4
Cunninghamella echinulata (Matr.) Thaxter	.9		19.7	3.5
Cunninghamella elegans Lendner	22.4	2.2	26.4	4.3
Mortierella bainieri Costantin				.7
Mortierella isabellina Oudemans	3.7	5.6	1.1	5.0
Mortierella ramanniana (Moel.) Linnemann		2.2		
Mortierella vinacea Dixon-Stewart	4.9	11.1	1.1	.7
Mucor fragilis Bainier			1.7	.7
Mucor mucedo (L.) Brefeld				.7
Phytophthora cinnamomi Rand				
Pythium splendens Braun				.7
Pythium ultimum Trow				.7
Pythium sp.		2.2	.6	4.3
Pythium sp.	.3			.7
Pythium sp.	.3			
Rhizopus arrhizus Fischer	2.0	5.6	40.4	20.0
Rhizopus nigricans Ehrenb.			.6	
Syncephalastrum racemosum (Cohn) Schroet.			.6	1.4
Zygorrhynchus vuillemini Namys.	4.6	7.8	5.1	.7
ASCOMYCETES				
Chaetomium ampullare Chivers	.3			
Chaetomium fusiforme Chivers			.6	.7
Chaetomium globosum Kunze ex Fr.			1.7	1.4
Melanospora episphaeria Phill. & Plow.	1.1		4.5	
Neocosmospora vasinfecta E. F. Smith	.6	10.0		14.2
Neurospora tetrasperma Shear & Dodge		1.1		
Pseudonectria diparietospora (described as new)				.7
Sordaria fimicola (Rob.) Ces. & de Not.				.7
Sporormia minima Auerswald			.6	.7
Thielavia terricola (Gilman & Abbott) Emmons		10.0	1.1	22.7
BASIDIOMYCETES				
Pellicularia filamentosa (Pat.) Rogers	.3		1.7	
Schizophyllum commune Fries	.3			
FUNGI IMPERFECTI				
Acremonium vitis Cattaneo	.3	2.2		
Alternaria humicola Oudemans	.6		1.7	1.4

TABLE III—*Continued*

	Forest		Cult. fields	
	N. Ga.	S. Ga.	N. Ga.	S. Ga.
Nos. plates	348	90	178	141
Nos. samples	15	8	10	12
FUNGI IMPERFECTI—*Continued*	%	%	%	%
Alternaria tenuis Nees ex Fr.	2.9		5.1	5.0
Aspergillus amstelodami (Mang.) Thom & Church				.7
Aspergillus carneus (van Tiegh.) Blochwitz				1.4
Aspergillus clavatus Desm.	.3			.7
Aspergillus conicus Blochwitz				1.4
Aspergillus flavipes (Bain. & Sart.) Thom & Church			.6	.7
Aspergillus flavus Link ex Fr.	12.9	10.0	27.5	10.6
Aspergillus fumigatus Fres.	1.4	4.4	28.7	45.4
Aspergillus janus Raper & Thom				2.1
Aspergillus niger van Tieghem	2.6		9.0	2.1
Aspergillus ochraceus Wilhelm			1.1	1.4
Aspergillus rugulosus Thom & Raper		1.1	.6	15.6
Aspergillus sydowi (Bain. & Sart.) Thom & Church	1.4	3.3		.7
Aspergillus tamarii Kita	.6		3.4	
Aspergillus terreus Thom	.6	7.8	14.6	12.8
Aspergillus ustus (Bain.) Thom		1.1	5.1	15.6
Aspergillus versicolor (Vuill.) Tiraboschi				2.1
Botrytis bifurcata (described as new)				.7
Candida sp.	.9			
Cephalosporium acremonium Corda	.6	2.2		.7
Cephalosporium sp.	.3		1.1	2.1
Cephalosporium sp.	.3			.7
Chloridium apiculatum (described as new)	.3		.6	.7
Cladosporium herbarum Link ex Fr.	2.9		11.2	15.6
Colletotrichum graminicolum (Ces.) G. W. Wilson				.7
Coniothyrium fuckelii Sacc.				4.3
Coniothyrium sp.				.7
Coniothyrium sp.				.7
Curvularia geniculata (Tracy & Earle) Boedijn		1.1		
Curvularia lunata (Wakk.) Boedijn	1.4	3.3	1.7	5.0
Curvularia trifolii (Kauffm.) Boedijn			1.1	
Cylindrocarpon radicicola Woll.	.3			
Cylindrocladium acoparum Morgan			.6	
Epicoccum nigrum Link	.3			4.3
Fusarium lateritium Nees ex Fr. emend. Snyder & Hansen			1.1	
Fusarium moniliforme Scheldon emend. Snyder & Hansen	.3	1.1	1.1	2.1
Fusarium nivale (Fr.) Ces. emend. Snyder & Hansen			3.4	.7
Fusarium oxysporum Schl. emend. Snyder & Hansen	.3	1.1	2.8	3.5
Fusarium solani (Mart.) Appel & Wr. emend. Snyder & Hansen		2.2	6.7	5.0

TABLE III—*Continued*

	Forest		Cult. fields	
	N. Ga.	S. Ga.	N. Ga.	S. Ga.
Nos. plates	348	90	178	141
Nos. samples	15	8	10	12
FUNGI IMPERFECTI—*Continued*	%	%	%	%
Fusarium tricinctum (Cda.) Sacc. emend. Snyder & Hansen		1.1	.6	1.4
Fusidium terricola (described as new)	.6		.6	2.1
Fusidium sp.				1.4
Geotrichum flavo-brunneum (described as new)	.3			
Geotrichum sp.	.3			
Gliocladium catenulatum Gilman & Abbott	.3		1.7	2.1
Gliocladium flavo-fuscum sp. nov.				1.4
Gliocladium roseum (Link ex Fr.) Bainier	18.1	3.3	3.9	16.3
Gliocladium virens (described as new)	.3		1.7	1.4
Gliomastix convoluta var. *felina* (Marchal) Mason			1.7	
Helminthosporium rostratum Drechsl.	.3			2.8
Helminthosporium sativum Pam., King & Bakke	.3			.7
Helminthosporium spiciferum (Bain.) Nicot	.6	1.1		7.8
Helminthosporium sp.			.6	
Helminthosporium sp.				1.4
Masoniella grisea (Smith) Smith				2.1
Memnoniella echinata (Riv.) Galloway				.7
Metarrhizium anisopliae (Metsch.) Sorok.	.6		.6	
Monilia sp.			1.1	.7
Monotospora sp.			1.7	1.4
Monotospora sp.			.6	2.1
Myrothecium roridum Tode ex Fr.			5.6	.7
Myrothecium verrucaria (Alb. & Schw.) Ditmar ex Fr.		3.3	4.5	7.1
Paecilomyces varioti Bainier	.6		1.1	4.3
Penicillium aculeatum Raper & Fennell	.3	1.1	.6	.7
Penicillium aurantiacum (described as new)				.7
Penicillium chrysogenum Thom		1.1		3.5
Penicillium citreo-viride Biourge			.6	
Penicillium citrinum Thom	2.0	1.1		4.3
Penicillium claviforme Bainier	.3			.7
Penicillium corylophilum Dierck	.3	3.3		.7
Penicillium crustosum Thom	.9			
Penicillium cyclopium Westling	.3		.6	2.1
Penicillium decumbens Thom	1.1	2.2		
Penicillium expansum Link emend. Thom	.3			
Penicillium frequentans Westling	5.2	10.0	1.7	2.1
Penicillium frequentans series	.6			
Penicillium funiculosum Thom	3.2	10.0	6.7	9.2
Penicillium fuscum (Sopp) Raper & Thom	.3		1.7	2.1
Penicillium herquei Bainier & Sartory	2.9	3.3	5.6	2.8
Penicillium herquei series	.3			
Penicillium janthinellum Biourge	17.8	4.4	6.7	31.9
Penicillium janthinellum series	.6			

TABLE III—*Continued*

	Forest		Cult. fields	
	N. Ga.	S. Ga.	N. Ga.	S. Ga.
Nos. plates	348	90	178	141
Nos. samples	15	8	10	12
FUNGI IMPERFECTI—*Continued*	%	%	%	%
Penicillium jenseni Zaleski	.6			1.4
Penicillium lanosum Westling	1.1	3.3	2.2	2.1
Penicillium lilacinum Thom	6.6	3.3	5.6	12.8
Penicillium martensii Biourge			.6	
Penicillium multicolor Grig.-Mano. & Porad.	6.6	1.1		2.1
Penicillium nigricans (Bain.) Thom.	3.1			.7
Penicillium oxalicum Currie & Thom	5.7	3.3	9.6	5.0
Penicillium puberulum Bainier			.6	
Penicillium purpurogenum Stoll	2.9	8.9	2.8	10.6
Penicillium raistrickii Smith	1.1	12.2		1.4
Penicillium restrictum Gilman & Abbott	3.4	3.3	2.2	5.0
Penicillium rubicundum (described as new)				.7
Penicillium rubrum Stoll	1.7		2.8	3.5
Penicillium simplicissimum (Oud.) Thom	1.4		3.4	
Penicillium spiculisporum Lehman			.6	
Penicillium spinulosum Thom	.6			
Penicillium steckii Zaleski	.3	1.1		4.3
Penicillium thomii Maire	2.9	7.8		.7
Penicillium variabile Sopp	.3	1.1	.6	.7
Penicillium vermiculatum Dangeard	.9	4.4	.6	3.5
Penicillium verruculosum Peyronel	6.6	3.3	1.1	5.7
Penicillium waksmani Zaleski	3.4	1.1	.6	1.4
Penicillium sp. *Carpenteles* series		13.3		7.1
Pestalotia guepini Desm.	2.0		1.7	
Pestalotia sp.	.3			
Phoma sp.	2.0	8.9	6.2	12.0
Phoma sp.				1.4
Phoma sp.				2.8
Pullularia pullulans (de Bary) Berkhout	.6		1.7	
Sclerotium bataticola Taub.			.6	.7
Sclerotium rolfsii Sacc.			.6	
Sclerotium sp.	.3			.7
Sclerotium sp.				.7
Scolecobasidium constrictum Abbott	.3		.6	.7
Sepedonium chrysospermum Lk. ex Fr.	.3			
Spicaria carnosa (described as new)	.3			1.4
Spicaria violacea Abbott	.3		2.2	
Sporotrichum sp.			.6	
Sporotrichum sp.	.3			
Stachybotrys atra Corda	.3	2.2	.6	11.3
Stemphyllium sp.		1.1		
Stemphyllium sp.				.7
Stemphyllium sp.				.7
Stysanus medius Sacc.		1.1	1.7	
Trichoderma viride Pers. ex Fries	16.7	16.7	24.2	9.9
Trichothecium sp.				1.4
Trichurus terrophilus Swift & Povah			.6	

The total number of microorganisms usually decreased rather drastically with soil depth (TABLE II). The cultivated soils, however, had greater total microorganisms at the 2 inch depth than at the surface (0–1 in.). Fungi in the alfalfa soil did not decrease with soil depth. The percentage of fungi in the total population did not drop off as rapidly with depth as did the bacteria and Actinomycetes.

Species of Fungi Isolated. The total number of species isolated was 165. Most of those enumerated are copious spore bearers and it is possible that they have a numerical advantage due to the methods employed in this investigation. The number of species in each class is given below.

Phycomycetes	22
Ascomycetes	10
Basidiomycetes	2
Fungi Imperfecti	131
Total	165

All of the fungi isolated are listed in TABLE III. No attempt was made to count the total number of colonies of each species in each plate. If the species occurred once or many times in a given plate it was counted as one occurrence for purposes of this table. Also, no attempt was made to obtain relative frequency of occurrence of any species in a soil sample.

TABLE IV

RELATIVE ABUNDANCE OF SELECTED FUNGI IN FOREST AND CULTIVATED FIELDS

	Plates	Forest	Cultivated fields
	Numbers	Percent	Percent
Mucorales	419	44.7	72.7
Aspergillus spp.	413	22.7	99.7
Penicillium spp.	667	91.1	89.3
Fusarium spp.	53	1.7	14.4
Trichoderma viride	130	17.5	17.9

Total plates 737, forest 418, cultivated fields 319.

Some of the chief genera and one order are brought together in TABLE IV. This shows that all groups except *Penicillium* were more common in cultivated fields than in forest soils. *Aspergillus* and *Fusarium* species are especially common in cultivated fields.

There were many isolations of apparently undescribed species. Some of these are described as new species. Other isolations had characters approximating those of fungi isolated only from plants. For ex-

ample, species of *Phoma* isolated from soil could be the common ones occurring on cotton, alfalfa or other plants in Georgia, but positive identifications could not be made without cross inoculations.

Botrytis bifurcata sp. nov. FIGS. 1, 2

Mycelia arachnoidia, effusa, sparsa, alba deinde grisea; conidiophoris erectis, septatis, divergenti-dichotomis ramosis, ramulis ultimis obtusis, parietibus brunneis; conidiis numerosis, sphaericis, hyalinis, 6–7 μ in diam., in glomerulis 50–70 μ in diam.; sclerotiis irregulariter, ellipticis vel globosis, glabris, circa 1–2 × 0.5–1 mm, superficiebus nigris, interioribus albis.

TYPE: No. 2065, from forest nursery soil, 12 inches deep, Davisboro, Ga., Sept. 14, 1956. A. A. Foster.

Mycelium arachnoid, sparse on most media, effused, hyaline later gray, with conidiophores 1–2 mm high and 9–12 μ wide, with brown walls, erect, septate, very divergently dichotomously branched in upper third, the ultimate branches obtuse and very short; conidia numerous, globose, hyaline, 6–7 μ in diam., in groups 50–70 μ in diam.; with sclerotia irregularly elliptical to globose, about 1–2 × 0.5–1 mm, with surface black with white interior.

Colonies on Czapek's agar floccose, very diffuse, fruiting sparsely. Both conidia and sclerotia form abundantly on corn meal agar. Few sclerotia develop on malt agar. Optimum temperature for sporulation is 25° C and few form at 30° C.

This species differs from *B. dichotoma* Corda in the presence of sclerotia and hyaline instead of yellow-brown conidia.

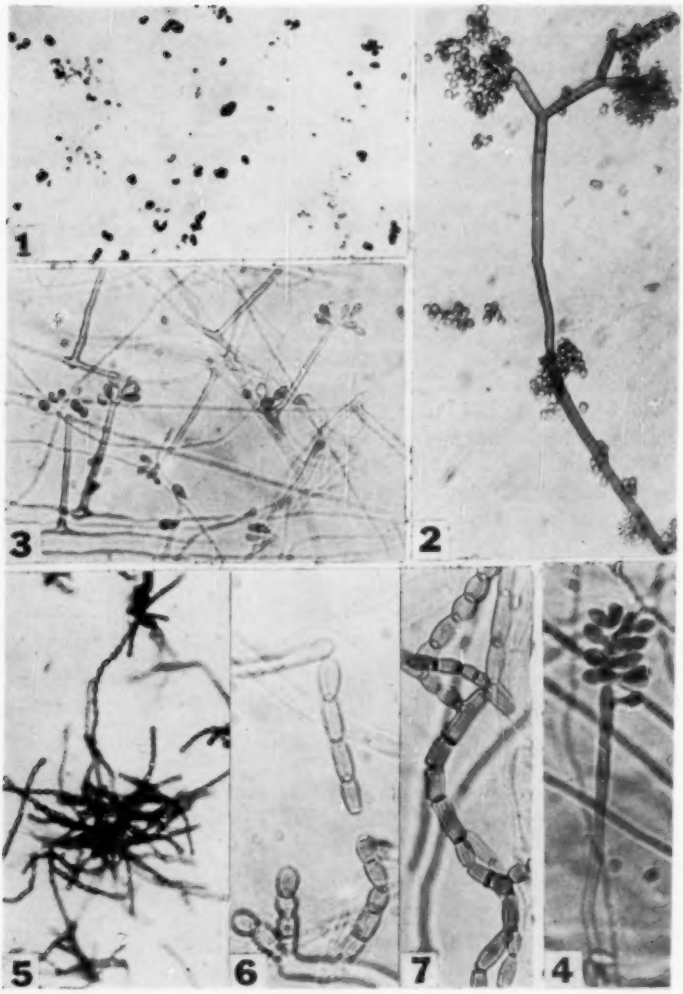
Chloridium apiculatum sp. nov. FIGS. 3, 4

Mycelia floccosa, fusca; conidiophoris erectis, simplicibus, septatis, 40–60 × 2.5–3 μ, a basi usque ad verticem conidogenis; conidiis obovatis, basi acuto-papillatis, pallide fuscis, numerosis, glabris, 5.5–7 × 2.5–3 μ.

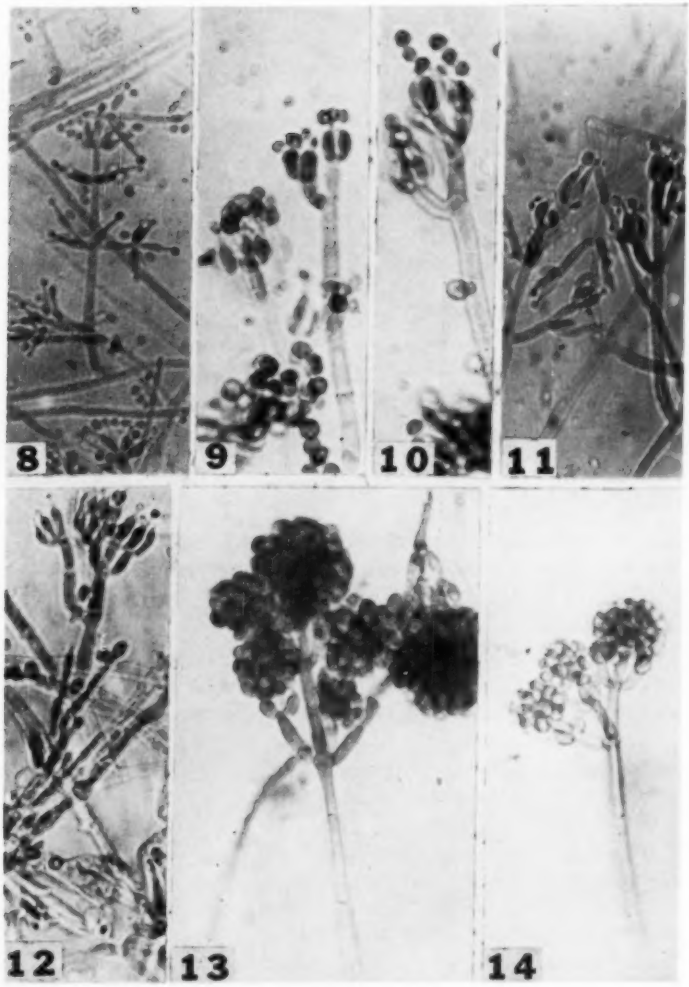
TYPE: No. 2805, from forest soil, Clarke County, Ga., May 6, 1956. J. H. Miller.

Colonies fuscous, of floccose mycelium of loose texture; with conidiophores distinctly erect, perpendicular to the basal mycelium, simple, sparsely septate, fuscous, 40–60 × 2.5–3 μ; with conidia borne on sides and apex on slight roughenings from near the base to the apex of the conidiophore, obovate with an acute, apiculate base, pale brown, copious, 5.5–7 × 2.5–3 μ.

This species sporulates profusely on corn meal or malt agar, but produces a deeper, more luxuriant colony on Czapek's agar.



FIGS. 1–7. 1, 2. *Botrytis bifurcata,* type. 1. Sclerotia, × 1. 2. Conidiophore and conidia, × 116. 3, 4. *Chloridium apiculatum,* type, conidiophores and conidia, 3 × 340, 4 × 640. 5, 6, 7. *Geotrichum flavo-brunneum,* type. 5. Colony structure with long conidial chains, × 130. 6. Development of chains from substrate mycelium, × 640. 7. Fertile hyphae separating into oidea, × 640.



FIGS. 8–14. 8. *Trichoderma viride* with divergent sterigmata. 9, 10, 11. *Gliocladium virens*, type, conidiophores with branches and appressed sterigmata and conidia. 12–14. *Gliocladium flavo-fuscum*, type. 12. Conidial structure, with branches, metulae and appressed sterigmata. 13, 14. Globose agglutinated masses of conidia attached to sterigmata. All figs. × 640.

This genus is not mentioned in Gilman's (**24**) book and most specific descriptions are in European literature indicating a habitat of plant parts. The American species, *Chloridium glaucum* Ell. & Ev., has smaller spores, 3–3.5 × 2 μ, and is described on oak wood.

Geotrichum flavo-brunneum sp. nov. FIGS. 5–7

Coloniae caespitulosae vel effusae, irregulariter, asterinoideae, vel simplices, flavo-brunneae; hyphis recumbentibus, septatis, ramosis filiformis; ramulis fertilibus elongatis et erectis vel procumbentibus, 56–140 μ longis; conidiis in catenis ramulosis productis, dilute-coloratis, breviter vel elongato-cylindricis, utrinque truncatis, glabris, 4–10 × 3–4 μ.

TYPE: No. 2808, in forest soil, 6 inches deep, Clarke County, Ga., May 6, 1956. J. H. Miller.

Colonies yellow-brown, in scattered stellate groups, 140–210 μ in diam., consisting of vegetative mycelium and long chains of conidia usually with no evident conidiophores, 56–140 μ long, occasionally branched; conidia formed by segmentation of fertile hyphae, elongate-cylindric with truncate ends, smooth, slightly colored, 4–10 × 3–4 μ.

On Czapek's agar very compact, thick, radially furrowed, light, finally dark snuff-brown, the culture medium becoming yellow, fertile hyphae few on margin. On corn meal agar or malt agar floccose, thin, in tangled masses, sporing profusely.

Gilman (**24**) reports only *Geotrichum candidum* Link from soil. This one differs from the above described species in colony color. *G. cinnamomeum* (Lib.) Sacc. has smaller spores.

Gliocladium virens sp. nov. FIGS. 9–11

Coloniae in agaro Czapekii lato-effusae, floccosae, laxe textae, viridae; conidiophoris erectis, penicillato-ramosis, asymmetricis vel symmetricis, 40–80 × 4–6 μ; metulis altitudinibus variis orientibus, 7–10 × 3–4 μ, glabris; sterigmatibus verticillatis, apicibus distincte attenuatis, 6–9 × 2.5–3 μ; capitulis globosis muco conglutinatis, 14–42 μ in diam.; conidiis ellipticis vel subglobosis, diluto-viridibus, glabris, 4–6 × 3–4 μ. Chlamydosporis globosis, 6–8 μ in diam.

TYPE: No. 167, in Norfolk cultivated soil, Bleckley Co., Ga., January 6, 1956. J. E. Giddens.

Colonies on Czapek's agar broadly effused, floccose with loose texture, dark green; with conidiophores erect, smooth, penicillately branched, either asymmetrical or symmetrical with branches or metulae single or verticillately arranged at different levels, 40–80 × 4–6 μ; with metulae 7–10 × 3–4 μ; with sterigmata in closely appressed verticels,

flask-shaped with apices drawn out to a tube, 6–9 × 2.5–3 μ; with globose heads of conidia held together in slime, 14–42 μ in diam.; conidia subglobose to distinctly elliptical, smooth, dilute green, 4–6 × 3–4 μ. Chlamydospores formed on slide cultures, globose, thin-walled, 6–8 μ in diam.

This differs from *Trichoderma viride* Pers. ex Fr. (FIG. 8) in penicillium-like sterigmata, closely appressed rather than divergent. Petch (**44**) in describing *Gliocladium penicilloides* Cda. says the conidia in *Gliocladium* are not borne in chains but singly, and collect in an apical globule supported by all of the phialides. No chains were observed in *Gl. virens*.

This species has larger spores than *Gl. deliquescens* Sopp. (3–3.8 × 2–2.5 μ), and lacks rough or pitted conidiophores. It differs from *Gl. atrum* Gilman and Abbott also in larger spores and in colony color, dark green rather than brown-green.

Gliocladium flavo-fuscum sp. nov. FIGS. 12–14

Coloniae in agaro Czapekii lato-effusae, laxe textae, floccosae, flavo-fuscae; conidiophoris erectis vel recumbentibus, simplicibus vel caespitosis, septatis, glabris, 80–100 × 4–6 μ; penicillato-ramosis, asymmetricis vel symmetricis, glabris; capitulis globosis, muco conglutinatis, 14–30 μ in diam.; metulis compactis vel divergentibus, 7–9 × 3–4 μ; sterigmatibus in utroque verticillo paucis, apicibus distincte attenuatis, 6–8 × 3 μ; conidiis ellipticis diluto-brunneis, glabris, 3–5 × 3–4 μ.

TYPE: No. 1263, from soil, 2 inch depth, Herty Nursery, Dougherty Co., Ga., August 2, 1956. A. A. Foster.

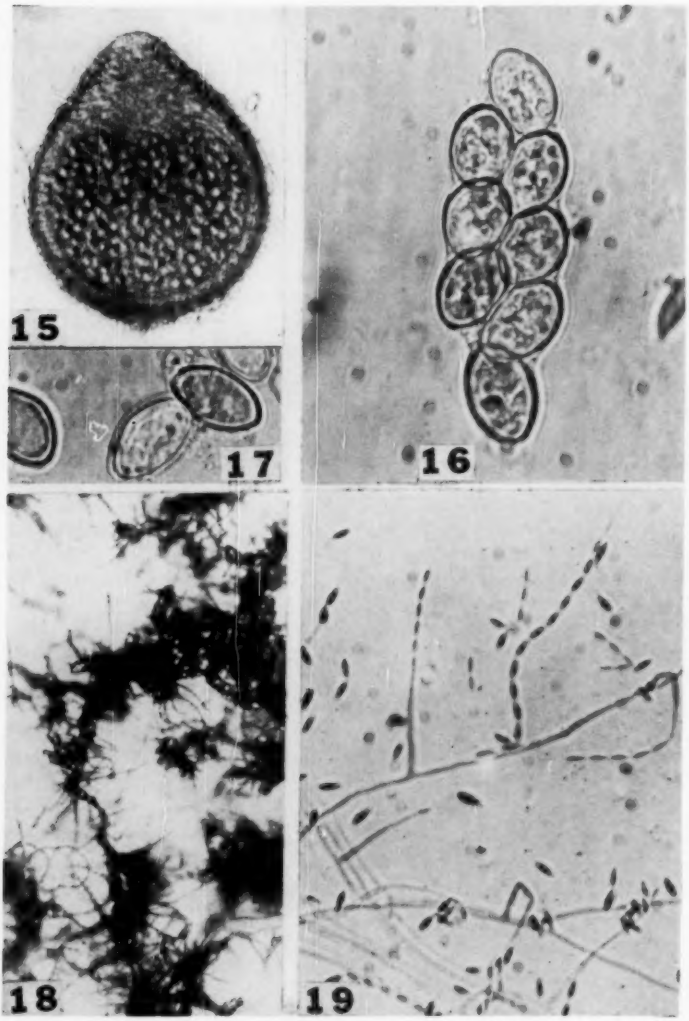
Colonies on Czapek's agar broadly effused, floccose with loose texture, light yellowish brown; with conidiophores erect or recumbent, single or in groups, septate, smooth, 80–100 × 4–6 μ; penicillately branched, asymmetrical or symmetrical; with globose to very irregular slimy heads of conidia, 14–30 μ in diam.; with metulae compact to divergent, 7–9 × 3–4 μ; with sterigmata flasked-shaped with attenuate apices, few in each verticil, closely appressed, 6–8 × 3 μ; with conidia subglobose, dilute brown, smooth, 3–5 × 3–4 μ.

Colonies fruit best on malt or corn meal agar, but produce more vegetative mycelium on Czapek's agar.

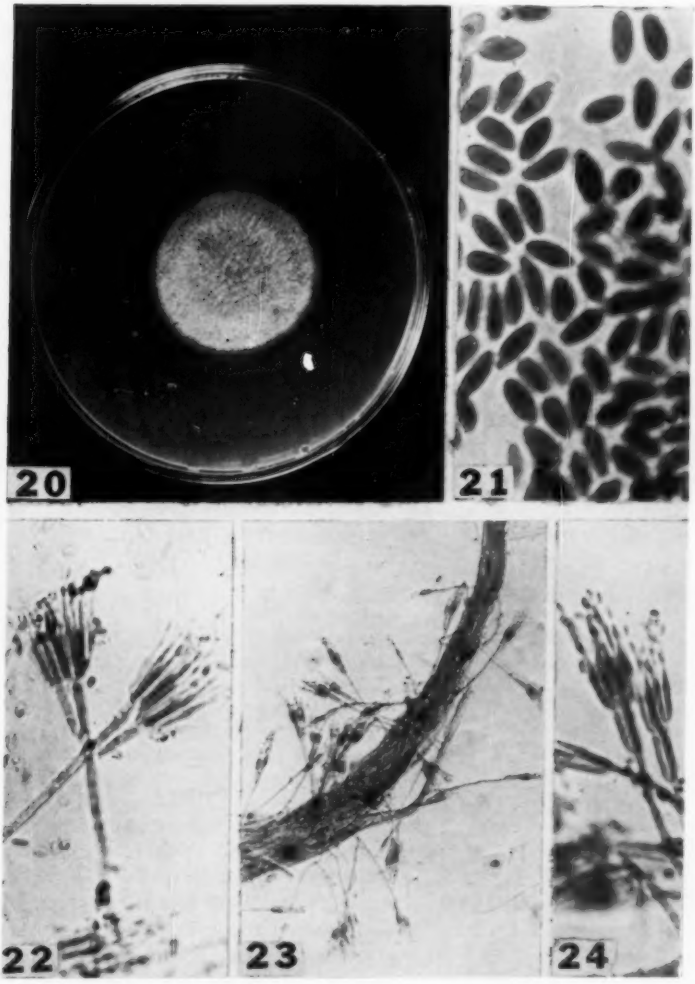
This differs from *Gl. virens* chiefly in colony color and in slightly smaller conidia.

Pseudonectria diparietospora sp. nov. FIGS. 15–17

Mycelia leviter floccosa vel plano-appressa, fusca; peritheciis superficialibus, globoso-conoideis, breviter papillatis, levibus, flavo-rufescentibus, circa 0.3–0.4 mm



FIGS. 15–19. 15–17. *Pseudonectria diparietospora*, type. 15. Perithecium with mass of ascospores showing through transparent wall, × 116. 16. Ascus with 8 ascospores, × 680. 17. Single ascospores showing double wall, × 680. 18, 19. *Fusidium terricolum*, type. 18. Colonies composed of tangled masses of conidial chains, × 149. 19. Substrate mycelium with conidiophores and chains of conidia, × 640.



FIGS. 20–24. *Penicillium aurantiacum*, type. 20. Colony at 10 days, × 0.6. 21. Conidia, × 2000. 22. Penicillus structure, with metulae and setrigmata with long tapering tubes, × 640. 23. Conidiophores arising from funiculose hyphae, × 140. 24. Conidial structure showing appressed branches, metulae and sterigmata, × 640.

latis et 0.4–0.5 mm altis; ascis late clavulatis, breviter stipitatis, parietibus tenuibus, octosporis, 60–80 × 19–22 μ; ascosporidiis ellipticis, distichis, continuis, hyalinis, parietibus crassis, duplicibus, levibus, 18–24 × 12–14 μ. Conidia ignota.

TYPE: No. 2067, in forest nursery soil, 12 inches deep, Davisboro, Ga., Sept. 14, 1955. A. A. Foster.

Mycelium lightly floccose or plane and appressed, thin, reddish-brown; with perithecia superficial, globose-conoid, with very short neck, smooth, yellowish-red, about 0.3–0.4 mm broad and 0.4–0.5 mm high; asci broadly clavate to spindle-shaped with very thin wall and short stalk, 8-spored, 60–80 × 19–22 μ; ascospores distichous, elliptical, continuous, hyaline, with thick, double wall, smooth, 18–24 × 12–14 μ. No conidia observed.

There are no paraphyses, but at a very early stage broad bands of connective tissue occupy the centrum. These soon deliquesce.

Perithecia form best on corn meal agar with very few on malt and almost none on Czapek's agar. On the latter the colony is dark brown and colors the agar in the entire plate dark reddish-brown.

Ainsworth and Bisby (2) cite *Pseudonectria* Seaver in place of *Nectriella* Sacc. for such species with one-celled hyaline spores.

Fusidium terricola sp. nov. FIGS. 18, 19

Coloniae in agaro Czapekii floccosae, primo albae deinde carnosae, myceliis filiformibus; conidiophoris simplicibus, attenuato-elongatis, erectis vel procumbentis, glabris, 10–30 × 2–3 μ; conidiis in longis, flexuosis, implicatis catenis fusiformibus, utrinque acutis, hyalinis, glabris, 3–6 × 1–1.5 μ.

TYPE: No. 2842, from soil, mixed forest, Clarke Co., Ga., May 6, 1956. J. H. Miller.

Colonies on Czapek's agar floccose, loose textured, at first white, later flesh-colored with filiform mycelium; conidiophores simple, narrowed toward the tip, arising from procumbent or aerial hyphae, erect or procumbent, smooth 10–33 × 2–3 μ; conidia developing basipetally in very long, flexuous chains, 70–100 μ in length, fusiform with very acute ends, hyaline, 3–6 × 1–1.5 μ. The chains in age become tangled masses and are very fugaceous.

This species is very common in soils in both south and north Georgia, especially when plated on plain agar.

The colony color and chains of conidia resemble very much the microspores of *Fusarium moniliforme*, but no *Fusarium*-like macrospores were observed in the cultures.

Penicillium aurantiacum sp. nov. FIGS. 20–24

Coloniae in agaro Czapekii aurantiacae, floccosae vel funiculosae, reverso aurantiaco deinde nigro-fusco, azonato; hyphis fertilibus sparsis, griseo-viridis; conidiophoris ex hyphis aereis orientibus, asperis, 30–80 × 3 μ; penicillis distincte asymmetricis, elementis omnibus dense confertis, 50–80 μ longis; metulis altitudinibus variis orientibus, 8–12 × 2.5–3 μ; sterigmatibus glabris, apicibus attenuatis, 10–14 × 2–2.5 μ; conidiis ellipticis, glabris, hyalinis, 3–4 × 2–2.6 μ, in catenis laxe parallelis vel implicatis.

TYPE: No. 1736, from soil, 6 inches deep, Davisboro nursery, Davisboro, Ga., August 31, 1955. A. A. Foster.

Colonies on Czapek's agar orange-pink to salmon orange (Ridgway Pl. 2) floccose-funiculose, 4–5 mm in diam. at 10 days at 25° C; reverse at first orange then brownish-black, not zoned, sporing areas light grayish green, sparse, chiefly in center of colony; conidiophores from ropes of aerial hyphae or when several colonies are in plate, developing from substrate hyphae between colonies, rough, reclining or erect, 30–80 × 3 μ; penicilli distinctly asymmetrical, 50–80 μ long, 1–2 branches and metulae oriented at different levels on the conidiophore, faintly echinulate, 8–12 × 2.5–3 μ; with sterigmata smooth, with attenuate apices, closely appressed, 10–14 × 2–2.5 μ. Sporulation is best on corn meal agar and very sparse on Czapek's or malt agar. Conidial chains tangled in age. Conidia elliptical, glabrous, hyaline, 3–4 × 2–2.6 μ.

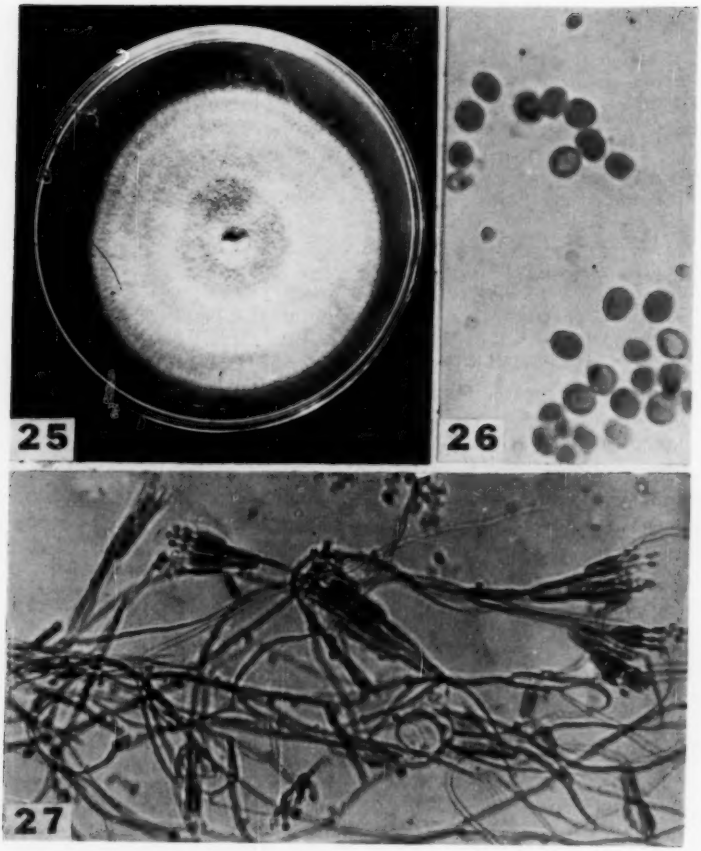
This differs from *P. pallidum* G. Smith in colony color and in having only the conidiophores roughened to any extent.

Penicillium rubicundum sp. nov. FIGS. 25–27

Coloniae in agaro Czapekii albae deinde rubicundae, floccosae, lato-zonatae; hyphis fertilibus sparsis, griseo-viridis; reverso aurantiaco-brunneo; conidiophoris ex hyphis recumbentibus vel aereis orientibus, glabris, 32–80 × 1.5–2 μ; penicillis plerumque biverticillatis et symmetricis interdum asymmetricis; metulis glabris, gracilibus, 6–7 × 1.5–2 μ; sterigmatibus parallelis, glabris, apicibus attenuatis, dense confertis, 7–9 × 2 μ; conidiis globosis vel subglobosis, glabris, hyalinis, 2–2.6 × 1.5–2 μ; in catenis implicatis.

TYPE: No. 2531, from soil 2 inches deep, Herty Nursery, Dougherty County, Ga., March 6, 1956. A. A. Foster.

Colonies on Czapek's agar at first white, later strawberry pink, Ridgway Pl. I, 2–4 cm in diam. at 10 days at 25° C, floccose, broadly zonate; reverse bitter-sweet to burnt sienna, Ridgway Pl. 2; conidiophores arise chiefly from aerial hyphae as short branches, or occasionally from substrate mycelium, 32–80 × 1.5–2 μ; penicilli biverti-

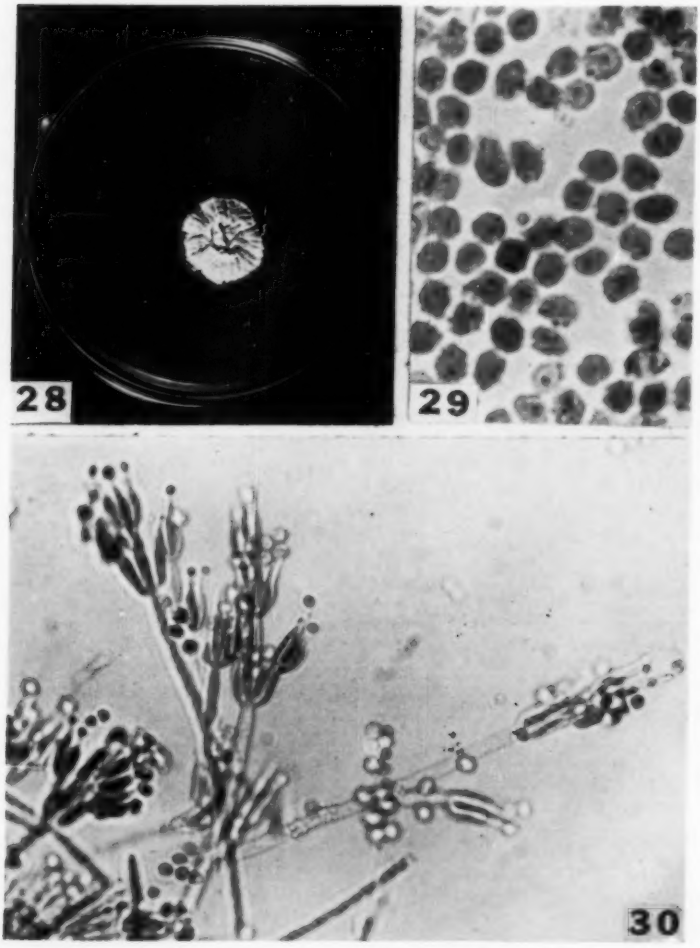


FIGS. 25–27. *Penicillium rubicundum*, type. 25. Colony at 10 days, × 0.6. 26. Conidia, × 1600. 27. Conidiophores developing from aerial mycelium, penicillus structure, biverticillate-symmetrical, with very slender branches, metulae and sterigmata, × 640.

cillate or sometimes asymmetrical with branches or metulae arising at different levels, all elements smooth, metulae 4–5, slender, 6–7 × 1.5–2 μ; sterigmata parallel-appressed, 7–9 × 2 μ with attenuate apices; conidia globose to subglobose, 2–2.5 × 1.5–2 μ, in tangled chains.

According to Raper and Thom (**46**) this species would be placed in the Biverticillata-symmetrica in the *P. herquei* series, but it differs

from all species in that series in the very small spores and very slender elements of the penicilli. Should it be considered asymmetrical it would be placed near *P. aurantio-candidum* Dierckx. It differs from that species also in the same characters.



FIGS. 28–30. *Spicaria carnosa*, type. 28. Colony at 10 days, × 0.6. 29. Echinulate conidia, × 2000. 30. Conidiophores with divergent metulae and long tapering sterigmata, × 640.

Spicaria carnosa sp. nov. FIGS. 28–30

Coloniae in agaro Czapekii restrictae, compactae, superficiae puvereae, azonatae, albae deinde carnosae, reverso nigro-viridis; conidiophoris ex hyphis repentibus in substrato vel aereis orientibus glabris, circa 70–200 × 2.5–3 μ; metulis verticillatis in conidiophoro ad altitudine varias orientibus vel singularibus, divergentibus, 6–9 × 2.5 μ, glabris; sterigmatibus apicibus acuminatis, glabris, 10–12 × 2–2.5 μ; conidiis globosis vel subglobosis, echinulatis, hyalinis, 2.5–3 μ in diam., in catenis laxe parallelibus vel implicatis, usque 80–200 μ longis.

TYPE: No. 2865, from forest soil, 6 inches deep, Clarke County, Ga., May 6, 1956. J. H. Miller.

Colonies on Czapek's agar very slow-growing at 25° C, white to later shell pink (Ridgway Pl. I between white and shrimp pink) 1–2 cm in diam. and 1–2 mm deep at 10 days, wrinkled, azonate, or more spreading and slightly floccose, powdery on top, no exudate, odor musty, reverse dark green. Conidial structures variable, in verticils, with long loosely parallel conidial chains, or in chains of spores from single sterigmata. Metulae chiefly at successive levels on conidiophore and at apex, divaricate, 6–9 × 2.5 μ, smooth; sterigmata with long tapering tubes, 10–12 × 2–2.5 μ, with tubes 3–5 μ long. Conidia subglobose to globose, echinulate, 2.5–3 μ in diam.

This species differs from *S. violacea* Abbott in the green reverse color of colony instead of yellow, and in rough spores, subglobose instead of elliptical and smooth. It also differs from *Penicillium humili* van Beyma in the rough spores and green reverse color of colony.

Cultures of all new species are placed in the American Type Culture Collection, Washington, D. C.

DISCUSSION

In this investigation the greatest number of species of fungi were isolated from rose bengal-streptomycin or Czapek's agar dilution plates. However, there were some slow-growing species that appeared on plain agar plates by direct inoculation that were soon covered up by fast spreaders on more enriched media. Results were similar to those of Farrow (**22**) in that inclusion of hemp seed or other plant parts did not materially increase the number of species, but a few different ones were obtained in this manner making it necessary to use various substrates. The use of Czapek's agar with streptomycin was advantageous for determining *Penicillium* species without subsequent transfers, but it did not limit colony size to the same extent as rose bengal agar and many Phycomycetes grew poorly on it.

Most of the species enumerated in TABLE III are chiefly spore

formers and it is possible that many mycelial forms were not discovered due to the isolation techniques employed in this investigation.

In general, the results reported here on numbers of fungi compared to bacteria and Actinomycetes agree with those of other workers. In any comparison of these data with those from other regions the soil reaction and soil organic matter content must be considered. Warcup (**64**) reported that most colonies of fungi develop from humus particles, and that humus content is a limiting factor for fungus growth in the deeper layers.

While fungi are not nearly so sensitive to soil acidity as bacteria and Actinomycetes, competition from these latter groups often lowers the fungal population as the acidity decreases.

The sharp decrease found in this study in numbers of microorganisms with soil depth was also noted in reports of many investigators. Waksman (**60**) found the numbers of fungi decreased with depth but not the species. In the present study the same species occurred at 12 and 24 inches as at 2 and 6. The only exception was possibly *Trichoderma viride*, which was isolated chiefly from the top 6 inches of soil.

Tresner et al. (**58**) found the greatest number of soil microorganisms in Wisconsin during winter and spring. Timonin (**57**) reported more bacteria in Manitoba soils in May than later in September, while more fungi were present in September. Smith and Gall (**48**), working with Florida soils, found numbers of bacteria to decrease when the mean monthly temperature was above 70° F. All of these reports involved different soil temperatures and moistures from those reported for Georgia. In the Georgia samples the soil microorganisms increased in the summer samples except the Actinomycetes which were in greater numbers in some soils during the winter months.

The number of species of fungi isolated was approximately the same or slightly greater than that found by Abbott (**1**), Bisby et al. (**9, 10**), Farrow (**22**), Jensen (**29**), Warcup (**66**) and others; so it is possible that most of the soil-inhabiting fungi, except of course the Basidiomycetes and possibly some other mycelial forms, were discovered. Most of the genera and many of the species are those reported in other such lists. The order of dominance, however, shows some variation. In considering all samples the order of occurrence for the chief genera was *Penicillium, Aspergillus, Cunninghamella, Trichoderma, Rhizopus, Gliocladium* and *Fusarium*. Abbott (**1**) in Louisiana and Werkenthin (**67**) in Texas both found *Aspergillus* dominant. Waksman (**60**) in New Jersey lists *Penicillium, Mucor, Aspergillus, Trichoderma, Clado-*

sporium, Fusarium etc. in that order. Bisby et al. (**9, 10**) for Manitoba found the order to be *Penicillium, Fusarium, Trichoderma, Rhizopus, Cladosporium* and *Aspergillus*. From these and other reports it appears that *Aspergillus* species are dominant in warm climates and *Penicillium* species constitute the chief soil fungi in cold regions. In this study *Aspergillus* species were the most abundant in all cultivated fields, while *Penicillium* species greatly exceeded them in forest soils.

PHYCOMYCETES—These were found in greater abundance in cultivated fields than in forests. This was especially true of *Rhizopus arrhizus* and *Cunninghamella echinulata,* while *Mortierella, Absidia,* and *Zygorhynchus* species appeared chiefly in forest soils. The Waksman (**60**) report shows more Phycomycetes of most genera in cultivated fields and only *Mucor* spp. in forest soils. Paine (**42**) compared open pasture land with woodland and found *Mucor* spp. more abundant in the forest areas. Tresner et al. (**58**) found no *Rhizopus* species in Wisconsin forest soils, but did find *Absidia, Mucor, Mortierella* and *Zygorhynchus* species. They also found that the Mucorales decreased from the pioneer to the climax stand, while *Penicillium* species increased.

Abisidia spinosa was very common and produced zygospores readily on potato-dextrose agar. Christenberry (**17**) found, on the other hand, *A. cylindrospora* Hagem in North Carolina, which is morphologically similar but differs in being heterothallic. *A. butleri* has been found in Louisiana and Texas but is not in the Christenberry list.

Mortierella isabellina was the common species in many samples. *M. vinacea* has been reported before from New Zealand (Gilman **24**), England (Warcup **64**) and Manitoba (Bisby et al. **9**).

In most soil lists *Rhizopus nigricans* is the common species, but *R. arrhizus* was the chief one in Georgia soils.

Choanephora conjuncta was found in a 6 inch sample from Dougherty County in a cultivated field and in a 24 inch sample from a forest soil in Clarke County. This is a valid species according to Hesseltine [3] (in litt.) and is not synonymous with *C. cucurbitarum* (Berk. & Rav.) Thaxter. Couch (**19**) described *C. conjuncta* on fading flowers of *Hibiscus syriacus*. It has not been reisolated until the present study.

Phytophthora cinnamomi was isolated from a single attempt by the apple technique of Campbell (**13**). According to the latter the fungus is widespread in soils of shortleaf pine stands affected by the littleleaf disease.

Conidiobolus villosus was obtained from Magnolia soil, Bleckley

[3] D. C. W. Hesseltine, Mycologist, U. S. Department of Agriculture, A. R. S., Northern Utilization Research Branch, Peoria, Ill.

County and from Cecil soil, Clarke County, both from cultivated fields. It apparently has not previously been found in soils.

ASCOMYCETES—The chief species isolated were *Neocosmospora vasinfecta* and *Thielavia terricola*. Both appeared frequently in plain agar plates, especially from south Georgia soils. This *Thielavia* has been found in Iowa, Louisiana and Texas and China, but the *Neocosmospora* species has been obtained from soil only from India (Gilman **24**).

Melanospora episphaeria was described and illustrated by Martin (**34**) from a culture obtained from surface litter in England. The lack of the characteristic beak of the perithecium and the reticulate spores indicate a relationship with *Gelasinospora* and *Neurospora* rather than with the *Nectriaceae*.

Neurospora tetrasperma was found only from a sample from an island in the Okefenokee Swamp.

Ascomycete stages of *Penicillium* and *Aspergillus* are placed in the Fungi Imperfecti with the conidial stages in TABLE III. A *Penicillium* producing a yellow colony with very few conidiophores but masses of sclerotia was of frequent occurrence in south Georgia samples from both forest and cultivated soils. After about four or five weeks the sclerotia develop into cleistothecia producing asci from the center out on short branches of ascogenous hyphae. The species should probably be placed in the *Carpenteles* series.

P. vermiculatum and *A. rugulosus* were very common in south Georgia samples. Both produced ascospores readily.

BASIDIOMYCETES—The methods employed in this investigation were not successful in isolating Basidiomycetes. *Rhizoctonia solani*, the nonsporulating stage of *Pellicularia filamentosa*, was found once in a forest soil and four times in cultivated fields in spite of its occurrence on seedling cotton all over the state. (Abbott (**1**) and Bisby et al. (**9**, **10**) reported *Rhizoctonia* sp., but Farrow (**22**), Waksman (**60**), Werkenthin (**67**), Jensen (**30**), Morrow (**39**), Chaudhuri and Sachar (**15**) and Paine (**42**) reported no *Basidiomycetes*.

Warcup (**63**) obtained Basidiomycetes from soil plates prepared from soil collected beneath clumps of sporophores and occasionally isolated them directly from mycelium in the soil. Stenton (**50**) listed 37 colonies with clamp connections and four species, all in *Corticium*. They were at the 11–20 inch depth.

The writers found one colony of *Schizophyllum commune* and Abbott (**1**) found a *Marasmius*. It would seem from this and other reports that no satisfactory methods have been worked out for isolating this group from soil samples. It is not a question of failure to identify

them because of not producing sporophores in culture, because none of the sterile mycelia nor any of the Fungi Imperfecti had clamp connections. However, it is possible that some of the sterile mycelia may have been haploid stages of some *Basidiomycete*.

FUNGI IMPERFECTI—Most of the colonies on all plates were in this group, as is true of all other soil lists. Werkenthin (**67**) said species of *Aspergillus* were dominant in soil fungi of the South. He reported 115 isolations of *Aspergillus* and only 2 of *Penicillium* out of a total of 157. Abbott (**1**) listed 33.6% *Aspergillus* and 22.9% *Penicillium*. However, Morrow (**39**) had *Penicillium* dominant and *Aspergillus* second in a pine wood in Texas. In the present investigation *Aspergillus* species were dominant in cultivated soils and *Penicillium* in forests. Warcup (**64**) found most *Penicillium* species in acid soils and few in alkaline. This may account for the abundance of *Penicillium* species in forest soils.

The *Penicillium* species for the most part were ones common in many soil lists. *P. raistrickii* and *P. thomii* were found almost entirely in forest soils.

Fusarium species were very common in cultivated soils and rare in forests.

Cladosporium herbarum in this paper includes *Hormodendrum cladosporioides* (Fres.) Sacc. as a synonym (Brett **11**).

Metarrhizium anisopliae has been previously described from many insect hosts from many parts of the world but not from soil. Petch (**43**) cited spore measurements from many authors and gave a small-spored form of 5–7 × 2–2.5 μ and a large form of 10–14 × 3–4 μ. Spores of cultures from Georgia soils come within the former measurements. These were obtained from a Clarke County forest soil and from a forest nursery in Dawson County. On Czapek's agar or malt agar in Petri dishes the colonies consisted of many almost coalesced small sporodochia, 0.1 to 1 mm in diameter, each composed of coalesced chains of spores arising from a branched hyphal base. The structure is very much like that of *Myrothecium verrucaria* except that there are no setae and the spore masses are dry rather than glutinous.

Bisby (**5**) considered *Trichoderma koningi* Oud. and *T. lignorum* Tode ex Harz to be synonyms of *T. viride* Pers. ex Fr. All *Trichoderma* isolations were considered as *viride*. This species was common in all soil samples, and especially so in the first 6 inches in depth.

Monotospora cultures Nos. 212, 1885 and 2168 have dark ovoid aleuriospores borne in great numbers in the mycelium and on short lateral branches, and also very small hyaline spores borne in heads as in *Cephalosporium*. This differs from *M. brevis* (Gilman & Abbott)

Mason in not having verrucose mycelium and small hyaline spores in chains. The other cultures placed in this genus have only large globose aleuriospores and no *Cephalosporium* stage.

Bisby (**6**) cited *Stachybotrys alternans* Bon. as a synonym of *S. atra* and *S. cylindrospora* Jensen as a possible synonym. The writers use the name *atra* for forms that could be placed in the other descriptions. *S. subsimplex* Cke. as described by Bisby is probably different from the type. Dr. W. L. White [4] sent the senior author a photomicrograph of part of the type specimen, Ravenel 3368, from Darien, Georgia, on banana leaves. The spores were globose and rough. This fungus was not found in the present soil collections.

The only common genera of soil fungi reported by others not found in the Georgia soils were *Verticillium* and *Acrostalagmus*. Furthermore, these fungi have not occurred in diseased plants sent to the pathology laboratory of the University of Georgia in the past many years.

SUMMARY

For purposes of this investigation 45 composite samples of soil for determination of species of fungi were collected from the chief geographic regions and soil types found in forest and in cultivated fields of Georgia. In addition, 42 samples were taken for counts of the general groups of bacteria, Actinomycetes and fungi.

Rose bengal-streptomycin agar and plain water agar were found to be most valuable for isolating the greatest number of species of fungi. Thornton's medium was most suitable of those screened for making counts of the general groups.

The total number of fungi in proportion to the bacteria and Actinomycetes was greater in forest soils than in cultivated. The number in each group varied more with soil types than with the geographical regions. Bacteria and Actinomycetes decreased at a greater rate with depth of sampling than the fungi. In most samples all microorganisms were more abundant in summer than in winter.

There were 165 species of fungi isolated: 22 Phycomycetes, 10 Ascomycetes, 2 Basidiomycetes and 131 Fungi Imperfecti. These were obtained from plates, both by direct inoculation and from soil dilutions, except the *Phytophthora cinnamomi* which was isolated only through the apple technique.

Penicillium was the chief genus in forest soils, while *Aspergillus* was dominant in cultivated fields.

[4] Dr. W. L. White, deceased, formerly Mycologist, U. S. Army Quartermaster Corps Biological Laboratories, Philadelphia, Pa.

Some of the species had evidently not been previously reported in soil lists. Also, some are described as new in this paper. Other undetermined species could be either plant or animal parasites, and could not be identified without host inoculations, which were not done in this investigation.

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CAPILLITIAL FORMATION IN THE STEMONITACEAE[1]

IAN K. ROSS[2]

(WITH 16 FIGURES)

In view of the recent interest in the morphogenesis of simple organisms, it is surprising that so little attention has been given to the development of the fructifications of the Myxomycetes. In **1884** de Bary presented a review of the knowledge of sporangial formation up to that time, and since then there have been very few investigations on the development of myxomycete sporangia. Only one of these later investigations has been on a member of the Stemonitaceae, that of Bisby in **1914**.

During a recent investigation of the position of meiosis in the Myxomycetes (Wilson and Ross, **1955**), abundant material was available for a study of the development of the capillitia of *Stemonitis, Comatricha,* and *Lamproderma.*

MATERIALS AND METHODS

The species used in this investigation are: *Stemonitis pallida* Wing., *S. herbatica* Peck, *S. fusca* Rost., *S. Smithii* Macbr., *Comatricha typhoides* (Bull.) Rost., and *Lamproderma arcyrioides* (Sommerf.) Rost. The system of classification used is that by Martin (**1949**) in North American Flora.

Fruiting plasmodia and immature sporangia of all species were collected from old, rotten wood either in the field or from wood brought into the laboratory. *S. pallida* was collected from wood culture in the laboratory and all the others from Mount Royal, Montreal.

The immature sporangia were smeared at intervals from the time of collection until maturity. All material examined was stained with aceto-orcein. The immature sporangia were picked up with needle-

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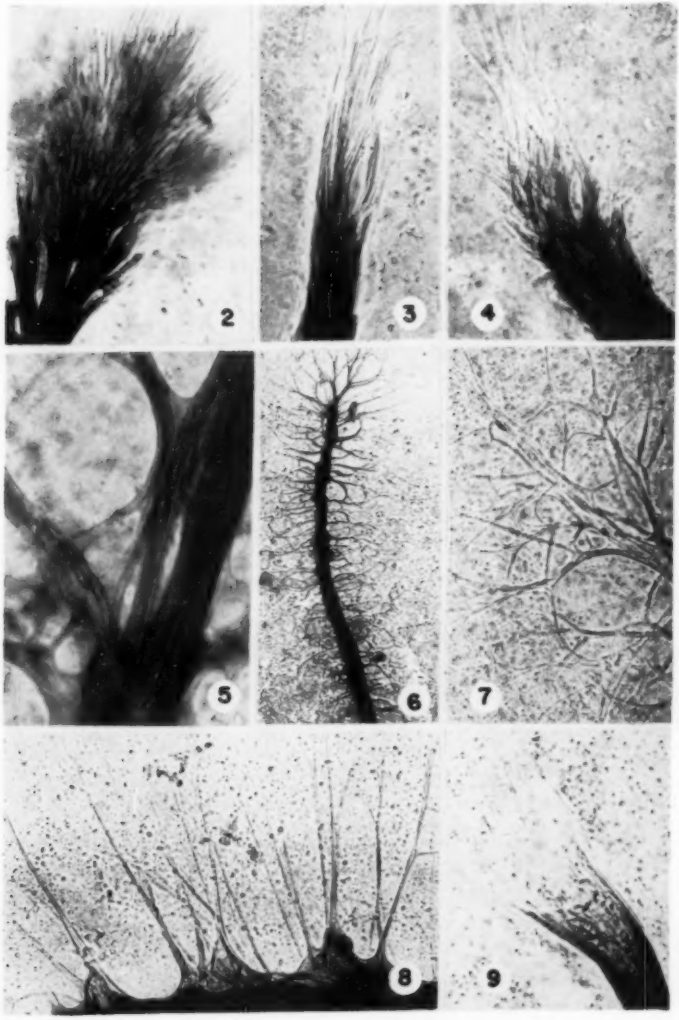
nose forceps and immersed in a drop of aceto-orcein on a slide. A No. 0 cover slip was placed over the preparation, and the slide was then briefly heated. Excess stain was removed by gentle squashing between sheets of absorbent paper. The preparation was then sealed with a gum mastic-paraffin mixture. Photomicrographs were made with a Spencer Research microscope and a Zeiss microscope equipped with apochromatic lenses. Photographs were made on Kodak Contrast Process Panchromatic film through a Wratten No. 58 (green) filter.

OBSERVATIONS

The initial stages of sporangial development in all species studied here are similar. The mature plasmodium, having reached a location favorable for fruiting, ceases flowing across the substratum and begins to form discrete clumps of protoplasm. The individual sporangial primordia are connected by a thin, continuous sheet of protoplasm. While the primordia are forming, the hypothallus is laid down underneath the connecting sheet, next to the substratum. As the protoplasm in the connecting sheet flows into the primordia, the hypothallus is left behind. The hypothallus rapidly dries out and becomes a thin, membranaceous sheet connecting the bases of the stalks of the sporangia (FIG. 1). The hypothallus extends under each sporangial primordium and continues up into each primordium as the stalk initial.

FIG. 1. *Lamproderma arcyrioides*, mature sporangia, stalks, and hypothallus, × 40.



FIGS. 2-9. *Comatricha* and *Stemonitis*. 2-8. *Comatricha typhoides*. 2. Stalk initial. 3. Apex of immature stalk. 4. Apex of immature columella. 5. Individual tubes bending out. 6. Mature columella. 7. Apical capillitial threads. 8. Elongation of lateral threads. 9. *Stemonitis Smithii*, stalk initial. All figures approximately × 200, except Fig. 5 at × 400, and Fig. 6 at × 50.

From this stage of development two types of differentiation are found in the Stemonitaceae, the *Comatricha* type and the *Stemonitis* type. In *Comatricha* the hypothallus is sheetlike when formed under the connective sheet of protoplasm, but under the primordium, at the site of the future stalk, the hypothallus develops as a system of hollow tubes. The stalk initial is thus composed of an interlaced mass of hollow tubes within the sporangial primordium (FIG. 2). The protoplasm surrounding the tubes continually adds material to the apices of the tubes, causing them to elongate upwards. The ends of the tubes are open and, in squash preparations, taper off into the cytoplasm (FIGS. 2, 3, 4). The tubes are apparently composed of a semi-solid substance when first formed, as is shown by the spreading of their tips when squashed (FIG. 2). While the stalk is being formed, the sporogenous mass of protoplasm elongates and starts to move up the completed part of the stalk. The mass of protoplasm soon leaves the hypothallus behind and continues to move up the stalk until the mature height is reached.

When the full height of the sporangium has been attained, tubes in the outer layer of the columella begin to bend outwards and form the lower, lateral, capillitial threads (FIGS. 4, 5). As the columella continues to be built up, other tubes bend out at intervals to become the intermediate threads. The columella usually reaches its maximum height in one to three hours. During this time there is no elongation of the lateral threads which have bent outwards (FIG. 6). At the top of the columella the tubes bend out and branch to form the apical threads of the capillitium (FIG. 7). Once the apical threads have formed, the lower, lateral threads begin to elongate and grow out to the periphery of the sporangium (FIG. 8). While the lateral branches are elongating towards the periphery, secondary branches arise from the apical threads and the wave of secondary branching proceeds rapidly down the sporangium.

The elongation of the lateral threads, however, is also very rapid, and the ends of the lateral threads reach the periphery of the sporangium before the wave of secondary branching and anastomosing has passed down the sporangium. The ends of the lateral branches reach the periphery first and do not anastomose with each other or with parts of the secondary branches, but remain free.

The diploid nuclei in the sporangium remain in the resting stage until the columella is mature. Once the capillitium forms at the apex of the sporangium, the nuclei enter prophase of meiosis. Meiotic divisions proceed down from the apex, along the periphery, and then inwards through the region of maturing capillitium.

Observations on *Lamproderma arcyrioides* indicate that it has a very similar type of development, but with a reduced amount of secondary branching. The capillitium of *Lamproderma* consists primarily of the major lateral threads arising directly from the columella.

The initial stages of development in the *Stemonitis* type are similar to those of the *Comatricha* type. The hypothallus, however, remains sheetlike under the sporangial primordia, and the stalk initial is a single tube (FIG. 9). The single tube is open at the apex and appears to have the same semi-solid nature as the apices of the tubes of *Comatricha*.

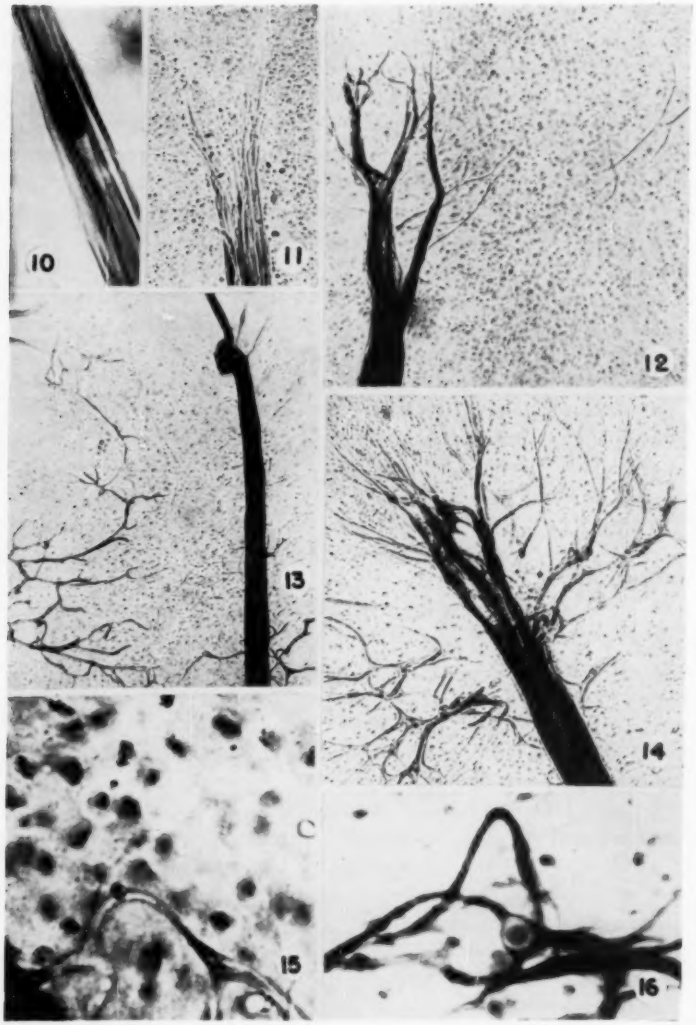
There was no evidence in any of the preparations of a membrane surrounding the stalk and separating the stalk from the apical protoplasm. Fragments of protoplasm, and even individual nuclei, are often trapped in the developing stalk and columella (FIG. 10).

The sporogenous mass of protoplasm moves up the completed part of the stalk until the mature height is reached, as in *Comatricha*. The columella is deposited as a single tube, but, unlike *Comatricha*, no capillitial threads are formed from the side of the columella. Once the columella has attained its maximum height, it splits into a system of tubes at the apex (FIGS. 11, 12). Each tube of the apical branching system is a continuation of one of the ridges or striations found on the developing columella (FIGS. 10, 11).

In *Stemonitis* the capillitium originates both from the apex of the columella and free in the surrounding cytoplasm (FIG. 12). The threads which arise free in the peripheral cytoplasm at the apex elongate and branch down the periphery of the sporangium (FIG. 13), while the threads which arise from the apical branches of the columella grow out towards the periphery (FIG. 14). The peripheral threads mature rapidly and anastomose almost completely to form the surface net characteristic of *Stemonitis*. While the peripheral net is developing, lateral branches commence to grow out from the columella towards the periphery (FIG. 13, bottom). These lateral branches reach the periphery after the peripheral net has formed there, and their ends fuse with the branches of the peripheral net.

The nuclei at the apex of the sporangium enter prophase of meiosis after capillitial formation has been completed in that region. Division proceeds as a wave downwards from the apex and inwards from the periphery. Because the peripheral part of the capillitium forms first, it is mature when the wave of meiotic divisions passes through, whereas the interior part of the capillitium is still immature (FIG. 15).

Nuclei are often trapped in the developing capillitium, usually at the junction of two or more threads (FIG. 16). These nuclei appear to



FIGS. 10–16. *Stemonitis.* 10. *S. pallida,* nucleus trapped in columella, × 1300. 11–15. *S. Smithii.* 11. Apex of columella, × 200. 12. Capillitial threads arising from apex of columella (left) and free in cytoplasm (right), × 200. 13. Capillitial threads growing inwards from periphery and outwards from columella × 200. 14. Capillitium branching down sporangium, × 200. 15. Meiosis I and maturing capillitium, × 1000. 16. *S. pallida,* nucleus trapped in capillitium, × 1800.

be enclosed in expansions of the capillitium. Groups of undivided nuclei are often found in regions of late maturing capillitium, after the majority of nuclei have divided.

In *Stemonitis, Comatricha,* and *Lamproderma* the outer membrane of the sporogenous mass remains thin and delicate throughout the development of the sporangium. The evanescent peridium of members of the Stemonitaceae is believed to form by a drying out of the outer membrane, with perhaps a deposit of waste materials from the peripheral cytoplasm, just prior to cleavage into spores. The peridium in the Stemonitaceae is not formed as a continuation of the stalk, but is a separate structure formed after the stalk, columella, and capillitium have matured. Occasionally, the peridium of *Comatricha* and *Stemonitis* will persist at the base of the sporangial head as a collar around the top of the stalk. The junction of this part of the peridium and the top of the stalk, however, is formed after the maturation of the stalk.

DISCUSSION

In the only detailed report of the formation of capillitia in the Stemonitaceae published previously, Bisby (**1914**) stated his belief that the capillitium originated from invaginations of the surface membrane and from the columella. Although evidence of invaginations and vacuoles may be destroyed by the squash technique, the observations of the present study do not seem to be compatible with such a theory. The apex of the stalk and columella and the ends of the capillitial threads of *Stemonitis, Comatricha,* and *Lamproderma* all appear to blend gradually into the cytoplasm surrounding them. If a membrane does surround the elongating ends of the columella and other structures, one would expect to find some evidence of it, even in squash preparations. The stalk, columella and capillitium of members of the Stemonitaceae are formed as intraprotoplasmic secretions, not as secretions through a membrane, or by the thickening of a pre-existing membrane.

The apex of the stalk of *Stemonitis* is open, as is shown by the nuclei and fragments of protoplasm which are often trapped in the developing stalk. The stalk is a tube secreted by the apical protoplasm of the sporangial primordium. More material is continually being added to the apex of the stalk as the stalk is built up by the apical protoplasm. The building up of the stalk at the apex in *Stemonitis* is somewhat similar to the formation of the stalk of *Dictyostelium* as described by Raper and Fennell (**1952**). This similarity, however, is not believed by the present writer to indicate any close relationship between these organisms.

The differences in the mature capillitia of *Stemonitis, Comatricha,* and *Lamproderma* are revealed by the differences found in the development of the capillitia of these genera. In *Comatricha* the lateral development of the capillitium begins by the outward bending of the tubes of the columella into the sporogenous protoplasm. Even though these tubes do not elongate further until secondary branching commences in the apex, they are already formed and can elongate very rapidly. This rapid development enables the lateral branches to reach the periphery of the sporangium before the wave of secondary branching is complete. Since each lateral branch develops individually, there is little anastomosing of these main lateral branches, and the outer ends remain free. In *Lamproderma* the lack of much secondary branching enables the major capillitial threads to grow to the periphery directly from the columella, with very little anastomosing.

In *Stemonitis* there are no individual tubes capable of bending away from the columella to form lateral branches. Lateral branches in *Stemonitis* do not arise from the columella until the columella has reached its full height, and only at the same time as the network is forming independently in the periphery of the sporangium. The apical and peripheral portions of the capillitium form at the same time, and the rapid wave of secondary branching and anastomosing is complete before the lateral outgrowths from the columella have had time to grow to the periphery. When the ends of the lateral branches do reach the periphery, the peripheral net is already there, and the ends of the lateral branches fuse with the net.

The development of the sporangia in the Stemonitaceae, from the initiation of the sporangial primordia to the completion of the columella, is in an upward direction. The primordium increases in height and the stalk and columella become taller as material is added to the apex, until the full height of the mature sporangium is reached. Once the columella is mature, however, the differentiation of the capillitium proceeds downwards. Until the upward differentiation of the columella is complete, the downward development of the capillitium is unable to begin. There would seem to be some regulatory mechanism which controls the type and direction of development. The presence of the two directions of differentiation at different times in the course of development and the relatively complex nature of the columella and capillitium formed by non-cellular, undifferentiated protoplasm make these organisms excellent subjects for morphogenetical studies.

Dennison (**1945**), in a study of the genus *Lamproderma,* believed *Comatricha* to be ancestral to both *Stemonitis* and *Lamproderma,*

The observations of the development of the capillitia of these genera in the present work support this theory. The stalk and columella in *Comatricha* and *Lamproderma* are essentially similar. The single tube of *Stemonitis* could possibly have been derived from the *Comatricha* type by a fusion of the several centers of protoplasmic activity into one center, producing a single large tube. Since there are no lateral tubes to produce lateral threads of the capillitium along the columella during the early stages of development in *Stemonitis*, the major part of the capillitium in *Stemonitis* comes from the secondary branching, and not from the major lateral threads, as in *Comatricha*.

On the other hand, the capillitium of *Lamproderma* consists primarily of the major lateral threads, which originate from the tubes of the columella. This type of capillitium could have been derived from the *Comatricha* type by a reduction in secondary branching, resulting in a simpler type of capillitium than found either in *Stemonitis* or *Comatricha*.

The stalk and capillitium of the members of the Stemonitaceae are produced by diploid protoplasm. Meiosis does not commence until the capillitium has formed at the apex of the sporangium (Wilson and Ross, **1955**). Although the wave of meiotic divisions passes rapidly down the sporangium and through regions of immature capillitium, the presence of groups of undivided nuclei and the nuclei trapped in the capillitial threads indicates that the differentiating processes are always under diploid control. The nuclei in the isolated groups eventually undergo meiosis, but the subsequent fate of the entrapped nuclei is unknown. It is possible that they eventually disintegrate.

Although de Bary (**1884**) commented on the fact that members of the Stemonitaceae differ from the rest of the Myxogastres in that a hollow cylindrical central column was formed inside the sporangial primordium, the significance of this has not been discussed in subsequent literature. The observations and illustrations of Welden (**1955**) show clearly that the stalk of *Didymium* and *Badhamia* is formed by a thickening of the membrane on the outside of the sporangial primordia. Unpublished work (**1957a**) on members of the Physaraceae, Cribrariaceae, Didymiaceae, and Trichiaceae indicates that the stalks of members of these families are also formed by a thickening of the membrane on the outside of the primordia. The hypothallus in these families is continuous with the stalk, but is formed on the upper side of the plasmodium, not on the under side as in the Stemonitaceae. The peridium in families other than the Stemonitaceae is continuous with the stalk, in fact, the

peridium is another part of the same membrane which forms the stalk and hypothallus.

As a result of the present investigation I believe the Stemonitaceae to be quite distinct from the rest of the Myxogastres. One of the basic differences between the Stemonitaceae and the other families is the position of the hypothallus. In the Stemonitaceae the hypothallus is formed beneath the plasmodium, in direct contact with the substratum, while in the other families, the hypothallus does not come into contact with the substratum until after the protoplasm has flowed from between the hypothallus and the substratum into the primordia.

In the Stemonitaceae the hypothallus projects up into the primordia from below, and consequently the stalk is formed on the inside of the primordium. In the other families, with a supra-plasmodial hypothallus, the membrane from which the hypothallus and stalk are formed is on the top of the plasmodium, and the sporangial primordia have to enlarge by welling up from beneath the membrane. The primordia are surrounded by the membrane which will form the exterior stalk.

The presence of a sub-plasmodial hypothallus and an interior stalk are characters which are common to all members of the Stemonitaceae studied here. These characters distinguishing the Stemonitaceae place the Stemonitaceae apart from the other families of the Myxogastres as a natural group, and indicate that the Stemonitaceae became separated from the other families early in the phylogenetical development of the Myxogastres.

Further developmental investigations on such forms as *Diachea*, and other genera whose family affinities are doubtful, together with developmental studies of the haploid stage (Ross, **1957b**), would aid materially in determining the natural groups and possible evolutionary trends of the Myxogastres.

SUMMARY

The development of the capillitia of *Stemonitis*, *Comatricha*, and *Lamproderma* is discussed. In all three genera the hypothallus is formed underneath the fruiting plasmodium. In *Comatricha* and *Lamproderma* the stalk is composed of an interlaced system of tubes, some of which bend out at intervals to form the lateral capillitial threads. The ends of these threads remain free. The capillitium of *Comatricha* and *Lamproderma* is derived primarily from the tubes originating from the columella. In *Stemonitis* the stalk is a single large tube, with no individual tubes to bend out and form lateral capillitial threads. The capillitium in *Stemonitis* arises from the apex of the columella and free in

the peripheral cytoplasm. The capillitium in the periphery anastomoses to form the characteristic surface net. The capillitium in *Stemonitis* is derived primarily from the free-formed threads in the cytoplasm. The Stemonitaceae are believed to be a closely related group, and to be quite distinct from the rest of the Myxogastres.

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GEOTRICHUM CANDIDUM[1]

J. W. Carmichael

(with 9 figures)

The genus *Geotrichum* was erected by Link in 1809 to include fungi with truncate spores ("Sporidia magna, extremitatibus truncatis genus designant"). He named only one species, *Geotrichum candidum,* from soil. Fries, in the Systema, did not accept the genus, merely noting that he could not distinguish it from mycelium. Persoon, **1822**, shortened and rephrased Link's description, but accepted the genus and species without change. Since that time there has been much confusion concerning the identity of this common fungus.

Different viewpoints on the complicated history of *Geotrichum* and especially *G. candidum* have been given by Berkhout, **1923**, Loubiere, **1924**, Ciferri and Redaelli, **1929**, Dodge, **1936**, Colonello, **1944**, Bobrov, **1951** and Windisch, **1951**. Windisch in particular gives many references to the literature. The inclusion of another survey here would add little that is new.

Suffice it to say that Link's illustration and description are inadequate to define the species unequivocally. There are no references in the literature which indicate that anyone else ever examined his original specimen or other authentic material. To the best of my knowledge, such material no longer exists. Thus, if we accept the original description and illustration as lectotype, an emendation in modern terms that would set the limits of the species and enable anyone to recognize *G. candidum* would be most useful. This paper attempts to provide such an emendation.

MATERIALS AND METHODS

Strains: Fifty-two strains of *G. candidum* were obtained from culture collections and by personal isolation. As far as possible strains were chosen to include isolates from widely varied substrata and diverse

[1] The majority of the work reported here is adapted from a doctoral thesis which was completed at Harvard University while the writer was recipient of a Professional Training Grant from the Department of Public Health of the Province of Alberta.

geographic areas. The majority originated in the United States, Germany and Canada, but a few strains came from England, Italy, Brazil and Japan.

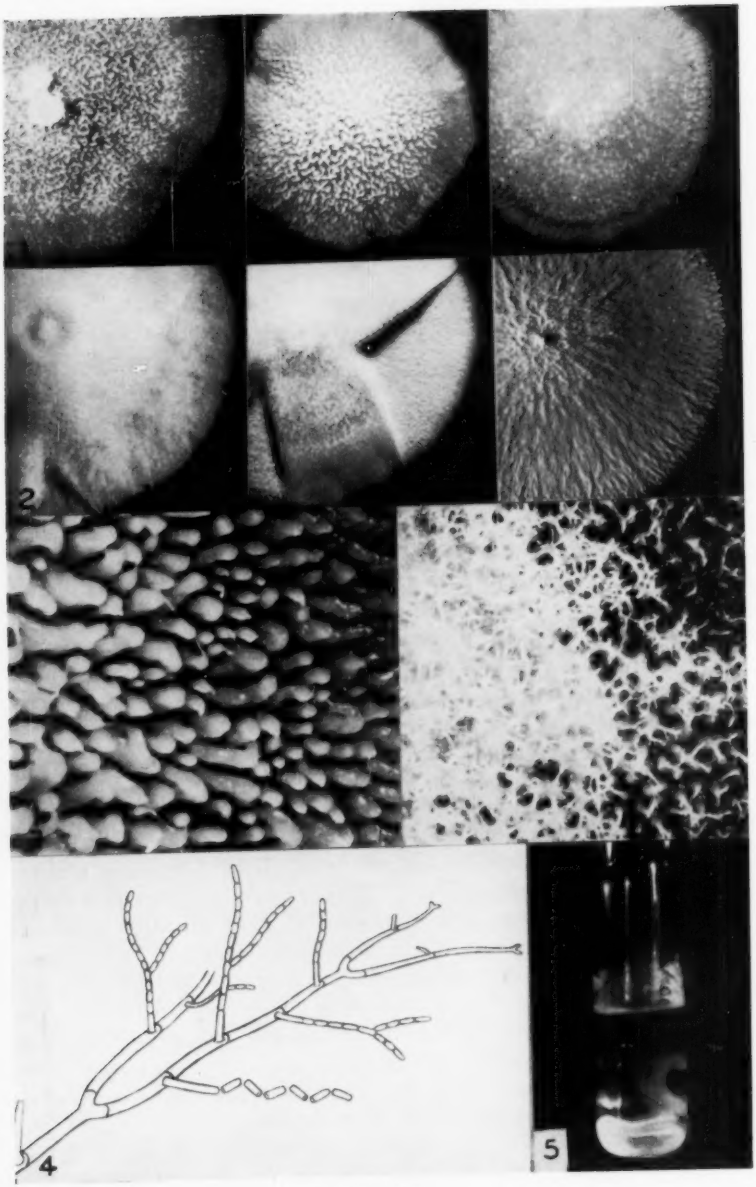
The sources of isolation were: sputum (13 strains), feces (3), skin (1), mouth (1), probably of human origin (9), milk (6), cheese (2), sewage treatment filters (5), sulfite waste (1), banana (1), cucumber (1), slime mold culture (1), soil (2), and not known (6).

Seven strains from the Centraalbureau voor Schimmelcultures were considered to be authentic cultures or types of synonyms for *G. candidum*. These were: *Oospora fragrans* var. *minuta* Berkh., strain Berkhout; *Geotrichum asteroides* (Cast.) Redaelli, strains Castellani and Redaelli; *Geotrichum javanense* Verona, strain Verona; *Geotrichum matalense* Cast., strain Castellani; *Geotrichum matalense* var. *chapmani* Cast., strain Castellani; and *Geotrichum versiforme* Moore, strain Moore.

Each of the 52 strains was studied on several media (see below) under carefully controlled conditions. Descriptions and photographs of 36 of the individual strains have been presented elsewhere (Carmichael, **1954**). Only a composite description will be given here.

MEDIA: *Littman's OSCV agar* and *Sabouraud's dextrose agar* were made up from the dehydrated products supplied by Difco. *Czapek's solution agar* was made up according to the formula in Thom and Raper (**1945**) except that dextrose was substituted for sucrose. *Corn meal agar* was made from yellow corn meal (40 gm) and agar (20 gm), by the following procedure: Bring one litre of water to boil, add corn meal and simmer 15 minutes. Filter through gauze into one litre graduated cylinder. Let stand 15 minutes. Siphon off and collect all but the last 200 ml which is discarded. Bring back to one litre; add agar, autoclave and dispense into Petri dishes. This medium is essentially the same as the one given by Conant et al. (**1954**), but avoids the slow, second filtration. *Dextrose-salts agar* was made up to contain 0.01% each of dextrose, sodium chloride, ammonium sulfate, and dibasic potassium phosphate, plus 100 μgm per litre of biotin, and 2% agar. The dextrose and a combination of the three salts were added as 1% stock solutions. *Dextrose-peptone broth* was made from dextrose 20 gm, bactopeptone (Difco) 10 gm, and Bromothymol blue 15 ml (use B.D.H. indicator solution or equivalent to give final dye concentration of 0.0006%) per litre. The medium was distributed in cotton-plugged culture tubes with gas inserts (Durham tubes) and autoclaved once only. It is light green in color when cool and turns blue when basic and yellow when acid. All media were autoclaved at 15 lbs for 20 minutes.

Culture Methods: All cultures were incubated in the dark at 25° C.



FIGS. 1–5.

Petri dishes were incubated in the inverted position (lid down). *Cultures on cellophane* were prepared by autoclaving small rectangles of uncoated cellophane, laying them on top of a solidified agar medium and inoculating the fungus on top of the cellophane (Carmichael, **1956**). Mounts from cultures were made in *lacto-fuchsin* (lactic acid 100 ml, acid fuchsin 0.1 gm. See Carmichael, **1955**).

GEOTRICHUM CANDIDUM Link ex Persoon *emend.*

Mycelium hyaline, septate, more or less specialized into broad, radiating, vegetative hyphae which branch dichotomously, and narrower, lateral, sporulating hyphae which may also branch (FIG. 4). On some media dichotomous branching may be depressed or absent.

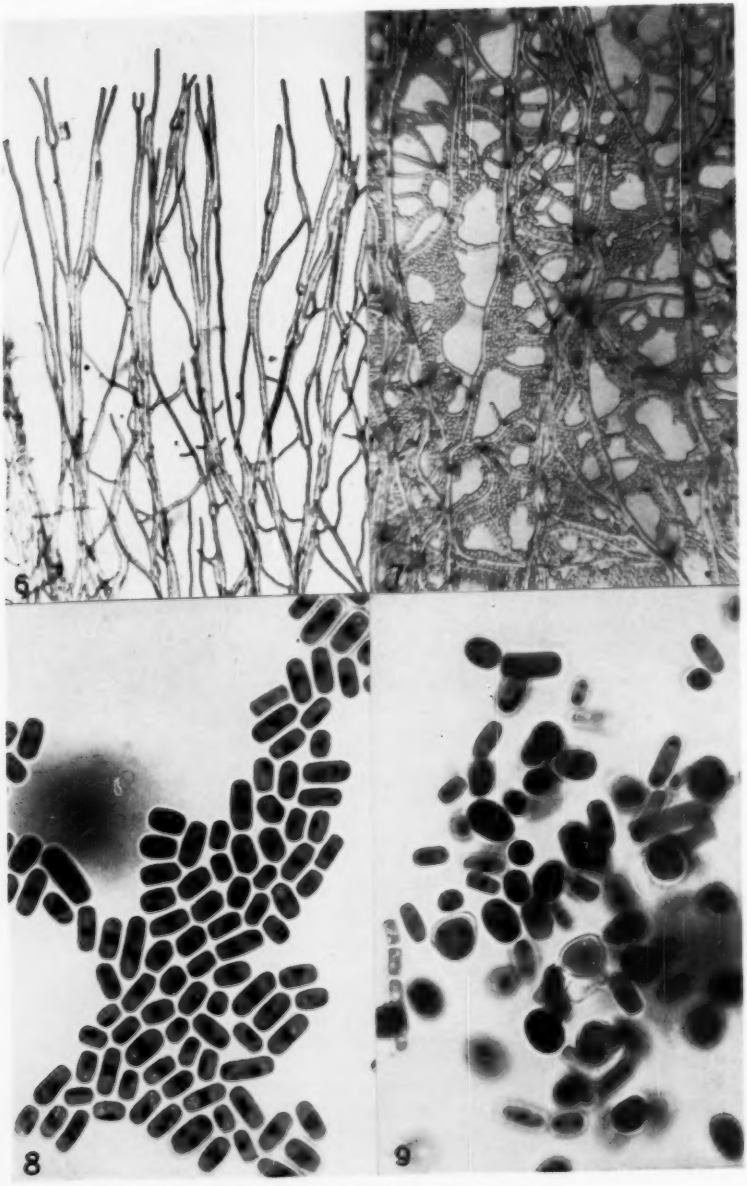
Spores formed in chains by disarticulation at the septa of the lateral hyphae, sometimes intercalary in the broad vegetative hyphae as well. Usually maturing in rapid basipetal succession. Plentiful, to scant or almost absent in some strains on some media. Spore chains may be aerial and erect, or decumbent, or flat on the surface of the medium (FIG. 7), or under the surface. Spores cylindrical at first, later varying from barrel-shaped to ellipsoidal or subglobose, 2–8 × 3–50 μ, commonly 3–6 × 6–12 μ (FIG. 8). There are 1–4, commonly 2, nuclei per spore.

Colonies on Littman's OSCV agar are flat or low dome-shaped, often with a pronounced central umbo of spines or white floccose mycelium (FIG. 1). They are never cerebriform or convoluted and rarely show radial grooves or ridges. The surface is frequently covered with spine-like aggregations of hyphae up to 3 or 4 mm high (FIG. 3) and is never completely smooth and textureless. The consistency is butyrous or membranous. Colonies are white or, if dye is absorbed from the medium, various shades of pale violet. Some strains also show a pronounced yellow color towards the center of the colony.

Growth rapid. Diameter 5–15 mm in 2 days, 10–30 mm in 5 days, and 25–50 mm in 10 days. Most strains 6–11, 15–20 and 30–40 mm respectively.

Colonies on Sabouraud's dextrose agar are white, flat and spreading, often with a central umbo (FIG. 2). They do not have convolutions or radial grooves, but sectors appear frequently. The surface may be

FIGS. 1–5. *Geotrichum candidum.* 1. Five-day colonies on Littman's OSCV agar showing morphology and strain variation, × 2.5. 2. Five-day colonies on Sabouraud's dextrose agar showing morphology and strain variation, × 1. 3. Close-up of texture on Littman's agar. Compare with Fig. 1, × 11. 4. Diagrammatic habit sketch. 5. Growth in dextrose-peptone broth showing ring, sunken pellicles and absence of gas, × 1.



FIGS. 6–9.

velvety, hairy, spiny or floccose, or it may even approach a dry powdery appearance. When disturbed with a transfer needle even the driest appearing colonies become slimy. Many strains give off a pronounced, but not unpleasant, fruity aroma.

Growth very rapid. Diameter 15–25 mm in 2 days, 40–65 mm in 5 days, and 75–90 mm (90 mm is to the edge of the plate) in 10 days. Most strains 17–22, 50–60, and 90 mm respectively.

Colonies on Czapek's solution agar are white or concolorous, effuse, and spreading, with an indistinct margin. The growth is mainly subsurface, but a scanty, floccose covering of aerial mycelium is usually present.

Growth rapid. Diameter 5–20 mm in 2 days, 20–40 mm in 5 days, and 35–70 mm in 10 days. Most strains 10–15, 25–35, and 40–60 mm respectively.

In dextrose-peptone broth at two days: acid, no gas, ring beginning to form, pellicle usually smooth, dry and powdery. At five days: acid, no gas, ring usually well developed as a thin film up the side of the tube, pellicle may be in any stage of formation or sinking (FIG. 5). At ten days: same as at five days. At three weeks: acid, in some strains a small amount of gas, ring and pellicle as before. In old cultures the reaction may finally become basic.

Microscopically, the growth in broth consists of hyphae, typical arthrospores, and larger, rounded, thick-walled cells (FIG. 9). These thick-walled cells are produced by enlargement of arthrospores. Their appearance sometimes suggests that they multiply by budding, but careful observation shows that budding does not actually occur. During the course of enlargement, the cells may shed one or more layers of wall material (FIG. 9).

On cellophane placed on dextrose-salts agar or corn meal agar the dichotomous branching of the radial hyphae is easily observed at the margin of the colony (FIG. 6). The characteristic chains of arthrospores are produced on the surface of the cellophane and in the air after 24 to 48 hours (FIG. 7).

HABITAT AND DISTRIBUTION: Ubiquitous in dairy products, soil and

FIGS. 6–9. *Geotrichum candidum*. 6. Colony margin on cellophane on dextrose-salts agar showing dichotomous branching of radial hyphae, × 125. 7. Older portion of colony showing sporulation on the surface of the cellophane. Aerial spore chains are present, but not in focus, × 125. 8. Spores in lacto-fuchsin from five-day colony on Sabouraud's agar. The nuclei and the relatively thick spore wall are visible, × 950. 9. Spores in lacto-fuchsin from five-day culture in dextrose-peptone broth. The spores are irregular in size and shape, and in some instances a layer of wall material is being shed as the cell enlarges, × 950.

other substrata. Saprophytic or pathogenic in the human respiratory and gastro-intestinal tracts.

TYPE: In the absence of an actual specimen, Link's description and illustration (**1809**) are selected as lectotype.

SYNONYMS: The following list of synonyms was compiled partly from the literature and partly from a study of named cultures (see materials and methods). In the great majority of cases the original descriptions were consulted, but even so, some of the names must remain doubtful because of the inadequacy of the descriptions. There are undoubtedly additional names in the literature that are based on strains of *G. candidum,* but the descriptions are too vague or inaccurate to indicate the relationship.

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Torula geotricha (Link) Corda, 1829. In Sturm, Deutschl. Fl. III Abt. (Pilze), 2 Bändchen, 8 Heft: 73.

Mycoderma malti-juniperi Desmazieres, 1825. Recueil Trav. Soc. Amateurs Sci., Agric., et Arts 317. Also published in Pl. Crypt. du nord de la France n. 102. 1826, and in Ann. Sci. Nat. **10**: 59. 1826, and in Observ. Bot. et Zool., Lille, 1826.

Oidium pulmoneum Bennett, 1842. Trans. R. Soc. Edinburgh **15**: 282–283. The above authority, frequently seen in the literature, is incorrect. Bennett gave a description of the fungus but did not propose a name. The name was probably proposed by A. Cattaneo in Miceti Trovati Sol. Corpo Humano, 126, but I have not been able to locate a copy of this publication.

Oospora pulmonea (Bennett) Saccardo, 1886. Sylloge **4**: 16.

Mycoderma pulmoneum (Bennett) Vuillemin, 1891. This name is cited by Dodge in his Medical Mycology 217. 1935, but I have been unable to find the original.

Monilia pulmonea (Bennett) Castellani & Chalmers, 1913. Man. Trop. Med. 2 ed. 829.

Geotrichum pulmoneum (Bennett) Basgal, 1931. Contr. Estudo Blastomycoses Pulmonares 49.

Oidium lactis Fresenius, 1850. Beiträge zur Mykologie **1**: 23.

Oospora lactis (Fres.) Saccardo, 1886. Sylloge **4**: 15.

Oosporoidea lactis (Fres.) Sumstine, 1913. Mycologia **5**: 53.

Endomyces lactis (Fres.) Windisch, 1951. Beitr. Biol. Pflanzen **28**: 121.

Oidium lactis var. *luxurians* Reiss, 1854. In Klotzsch, Herb. Myc. n. 1885.

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Geotrichum mycoderma (Bon.) Saccardo, 1886. Sylloge **4**: 40.

Coprotrichum purpurascens Bonorden, 1851. Handb. Algemeinen Mykologie 76.

Geotrichum purpurascens (Bon.) Saccardo, 1886. Sylloge **4**: 40.

Coprotrichum cinereum Bonorden, 1851. Handb. Algemeinen Mykologie 76.

Geotrichum cinereum (Bon.) Saccardo, 1886. Sylloge **4**: 40.

Torula alba Preuss, 1852. Linnaea **25**: 73.

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Mycoderma lactis-butyri Desmazieres, 1858. Pl. Crypt. de France n. 529.

Oidium obtusum Thümen, 1875. Mycotheca Universalis n. 289.

Oidium aceticum Ricketts, 1901. Jour. of Med. Res. **6**: 516.

Oidium nubilum Weigmann & Wolff, 1909. Zbl. f. Bakt. (2) **22**: 657.

Oospora nubila (Weigm. & Wolff) Berkhout, 1923. De schimmelgeslachten *Monilia, Oidium, Oospora* en *Torula* 50.

Oidium camemberti Maze, 1910. Ann. Inst. Pasteur **24**: 395.

Oospora camemberti (Maze) Berkhout, 1923. De schimmelgeslachten *Monilia, Oidium, Oospora* en *Torula* 48.

Oidium matalense Castellani, 1915. Lectures on the Higher Fungi, Royal Coll. of Phys., London.

Mycoderma matalense (Cast.) Brumpt, 1922. Precis Parasitol. 3 ed. 1084.

Oospora matalensis (Cast.) Berkhout, 1923. De schimmelgeslachten *Monilia, Oidium, Oospora* en *Torula* 50.

Pseudomycoderma matalense (Cast.) Ciferri, 1930. Arch. Protistenk. **71**: 442.

Geotrichum matalense (Cast.) Castellani, 1932. Jour. Trop. Med. Hyg. **35**: 279.

Pseudomonilia matalensis (Cast.) Dodge, 1935. Medical Mycology 295.

Trichosporon matalense (Cast.) Ciferri, 1955. Anais Soc. Biol. Pernambuco **13**: 140.

Geotrichum matalense var. *chapmani* Castellani, 1932. Jour. Trop. Med. Hyg. **35**: 279.

Endomyces lactis var. *matalense* (Cast.) Windisch, 1951. Beitr. Biol. Pflanzen **28**: 123.

Monilia asteroides Castellani, 1914. Jour. Trop. Med. Hyg. **17**: 307.

Oidium asteroides (Cast.) Castellani & Chalmers, 1919. Man. Trop. Med. 3 ed. 1095.

Mycoderma asteroides (Cast.) Brumpt, 1927. Precis Parasitol. 4 ed. 1212.

Geotrichum asteroides (Cast.) Basgal, 1931. Contr. Estudo Blastomycoses Pulmonares 48.

Not *Oospora asteroides* Sauvageau & Redais, 1892. Ann. Inst. Pasteur **6**: 250.

Oospora fragrans var. *minuta* Berkhout, 1923. De Schimmelgeslachten *Monilia, Oidium, Oospora* en *Torula* 47.

Not *Oospora fragrans* Berkhout, 1923. De Schimmelgeslachten *Monilia, Oidium, Oospora* en *Torula* 47.

Mycoderma nyabisi Mattlet, 1926. Ann. Soc. Belge Med. Trop. **6**: 30.

Geotrichum nyabisi (Mattlet) Basgal, 1931. Contr. Estudo Blastomycoses Pulmonares 49.

Mycoderma muyaga Mattlet, 1926. Ann. Soc. Belge Med. Trop. **6**: 28.

Mycoderma kieta Mattlet, 1926. Ann. Soc. Belge Med. Trop. **6**: 29.

Mycoderma issavi Mattlet, 1926. Ann. Soc. Belge Med. Trop. **6**: 26.

Geotrichum javanense Verona, 1933. R. Ist. Sup. Agrario di Pisa Boll. **9**(A): 977.

Geotrichum versiforme Moore, 1934. Ann. Missouri Bot. Garden **21**: 361.

DISCUSSION

Geotrichum candidum, as here emended, can now be recognized as a common fungus of world wide distribution and varied habitat. Medical mycologists in particular should welcome the knowledge that the great majority of *Geotrichum* strains which are isolated from the human respiratory and gastro-intestinal tracts belong to this one species. On Sabouraud's agar plates inoculated with clinical specimens, *G. candidum* can be identified in 24 to 48 hours by the rapidly growing, white colonies producing chains of arthrospores and showing dichotomous branching at the margin.

Undoubtedly much of the earlier confusion as to the identity of *G. candidum* was due to the great variation which is encountered in different strains. Windisch (**1951**) was the first to make a careful comparative study of this variation in a sufficient number of strains (17 strains of *G. candidum*) to realize that they should all be placed in the same species. However, he emphasized similarities to the extent that he included as varieties (var. *fragrans* and var. *klebahnii*) three additional strains which are morphologically and physiologically distinct. These strains do not belong to *G. candidum*, as defined here, and their position will be discussed in a future paper.

Windisch also reported the presence of asci and ascospores in *G. candidum* and proposed the new name *Endomyces lactis* for the perfect stage. It now seems doubtful that the structures he described actually represented sexual reproduction (Carmichael, **1954**, and Windisch, personal communication). However, in his letter Windisch reported that in one strain on one occasion he observed a definite and plentiful production of asci and spores, but that he has not been able to repeat the observation. It appears that the question of sexual reproduction in this species remains to be settled. Regardless of whether certain strains can reproduce sexually under special conditions, the name *G. candidum* can still be used for the asexual form usually encountered.

In his description of *G. candidum* Windisch emphasized physiological characters. The reader is referred to his paper for data on fermentation and assimilation tests. The dichotomous branching which so readily serves to separate this species from others in the genus is not mentioned as a diagnostic character. Further, the paucity of illustrations makes his paper somewhat unsuitable for the average worker who would wish to identify *G. candidum*. It is hoped that the emendation and illustrations presented here indicate the variation and salient characters well enough so that this common species will henceforth be recognized wherever it is encountered.

SUMMARY

Fifty-two strains of *Geotrichum candidum* have been compared on standard culture media. The species is illustrated and emended so as to separate it clearly from others in the genus. Link's original description and figure are chosen as lectotype. A list of 55 synonyms is appended.

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THE PEZIZACEAE OF THE MUSSOORIE HILLS (INDIA). V.

K. S. Thind, Edith K. Cash and J. S. Sethi

(with 9 figures)

This paper records additional species of the Pezizaceae from the Mussoorie Hills (6000–7500 ft. altitude in the Northwestern Himalayas) as a part of the study of the fungus flora of that region undertaken by K. S. Thind and his students. The first four contributions [1] describe 27 known species, one known variety and one new variety. This fifth contribution deals with three new species belonging to *Sphaerospora*, *Humarina* and *Humaria*. The fruit bodies are described from fresh material as well as from that preserved in alcohol-formalin. The numbers of the species are the serial numbers of the senior author's pezizoid flora of the Mussoorie Hills.

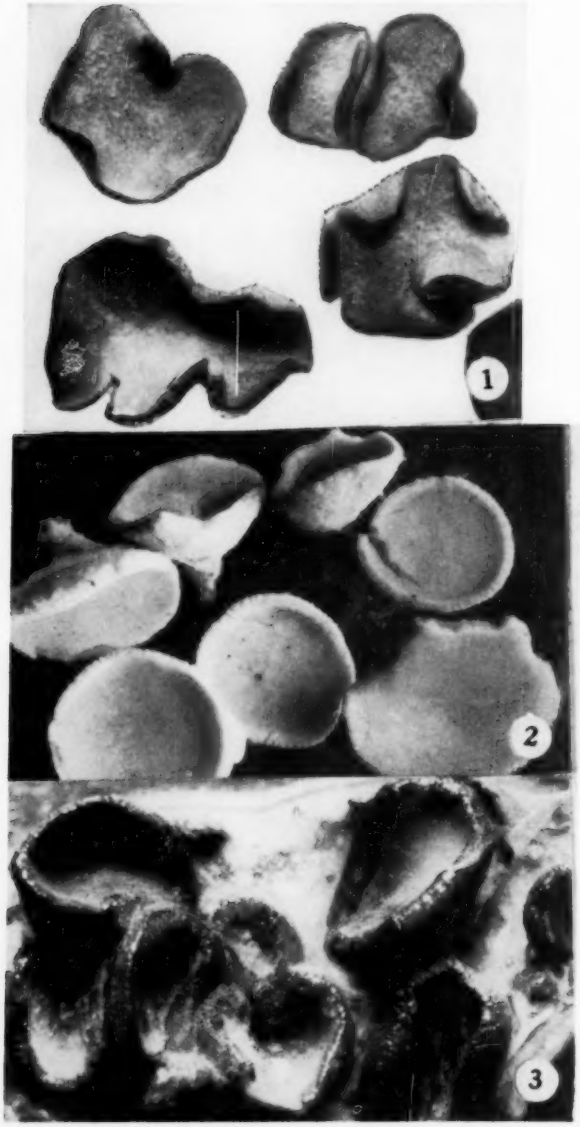
Type collections have been deposited in the Herbarium of the Panjab University. Duplicate material is in the U. S. National Fungus Collections, Beltsville, Maryland.

30. **Sphaerospora tuberculata** sp. nov.

Apothecia 4–8 mm diam., gregaria vel congesta, carnosa, sessilia, dimidio inferiori immerso, cupulata vel scutellata, vel pressione mutua distorta, extus rubra, tuberculata, pilosa, hyphis basalibus subhyalinis, flexuosis in humo radicata, margine dentato, hymenio rubro; pili breves, brunnei, simplices, rigidi, obtusi vel subacuti, usque ad $225 \times 9\,\mu$; asci cylindrici, ad apicem rotundati, basim versus attenuati, octospori, 165–210 × 15.8–17.5 μ; ascosporae uniseriatae, globosae, glabrae, subhyalinae, uniguttulatae, 12–15 μ in diam.; paraphyses subhyalinae, clavatae, simplices vel rare ramosae, usque ad $225 \times 7\,\mu$.

Apothecia mostly 4–8 mm, gregarious to closely crowded or congested, sessile, attached to the substratum by more than half of the lower side, periphery remaining free, regular when young, becoming much contorted later as a result of mutual compression, slightly cupulate to scutellate, fleshy; external surface red, hairy, tuberculate, attached by numerous hyphae; hairs brown, short, erect, simple, narrowed upward to obtuse or subacute apex, septate, thick-walled, wall up to 2.5 μ

[1] Papers by K. S. Thind and associates in the Journal of the Indian Botanical Society and Indian Phytopathology (in press).



FIGS. 1–3. Habit. 1. *Sphaerospora tuberculata*, × 5. 2. *Humarina cacaina*, × 3. 3. *Humaria mussooriensis*, × 4.

thick, up to 225 × 9 μ; hyphae hyaline to subhyaline, flexuous, septate; margin deep, slightly raised and inturned, appearing dentate and hairy from the inturned tuberculate lower surface; hymenium slightly concave to plane, smooth, red, concolorous to slightly lighter colored. *Asci* hyaline, cylindrical, apex rounded, tapering below into a stem-like base, bulging from pressure of the ascospores, operculate, not turning blue with iodine, 8-spored, 165–210 × 15.8–17.5 μ. *Ascospores* uniseriate, not overlapping, subhyaline, globose, smooth, uniguttate, guttule large and filling three-fourths to almost all of the spore cavity, 12–15 μ in diameter. *Paraphyses* subhyaline, clavate, enlarged at the tip, simple or rarely branched near the base, septate, up to 225 × 3.5 μ, reaching a diameter of 7 μ at the top. *Excipular cells* medium to deep brown, subglobose, up to 35 μ in diameter. FIGS. 1, 4, 7.

Collected on soil under cedrus forest (*Cedrus deodara* (Roxb.) Loud.): India (Kanatal, Mussoorie, Sept. 10, 1955, n. 161, TYPE).

The characters of this fungus do not agree with those of any described species of *Sphaerospora*. It is distinguished by red, small, gregarious to crowded apothecia attached to the soil by more than half of the lower side, hairy and tuberculate external surface, and hyaline, globose, smooth spores with one large guttule. It differs from *S. brunnea* (Alb. & Schw. ex Fr.) Mass. in its conspicuously tuberculate outer surface, red hymenium, and its occurrence on ordinary soil. It differs from *S. patagonica* Rehm in its smaller spores and from the other red species of the genus in its smooth spores.

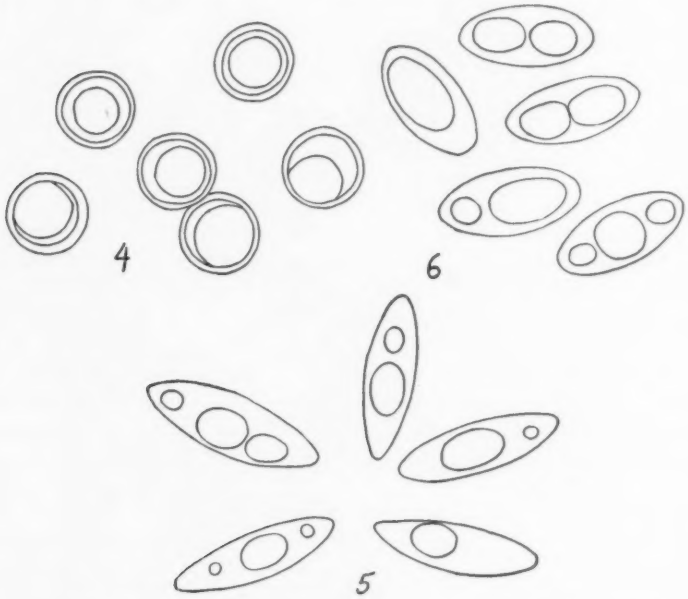
31. **Humarina cacaina** sp. nov.

Apothecia usque 1 cm in diam., gregaria, caespitosa, subsessilia, carnosa, fragilia, subcupulata dein repanda, pallide cacaina, extus pubescentia, stipite brevi, cylindrico, rugoso, margine crenato vel minute dentato, hymenio obscuriori; asci cylindrici, operculati, octospori, 275–320 × 13–17.5 μ; ascosporae 1–2-seriatae, subhyalinae, glabrae, 1–3-guttulatae, late fusoideae, apicibus attenuatis acutisque, 25.3–33 × 7.8–10 μ; paraphyses filiformes, simplices vel ramosae, brunneo-guttulatae, usque 315 × 3 μ.

Apothecia up to 1 cm in diameter, gregarious, caespitose, subsessile, shallow cup-shaped, eventually becoming repand on full expansion, light brown, or light chocolate brown, fleshy, brittle; stipe short, cylindrical, thick, solid, pubescent, rough, up to 5 × 2 mm; external surfaces pubescent, rough; pubescent hairs white, short, straight to flexuous, septate, unbranched, up to 200 × 11 μ; margin crenate or minutely dentate; hymenium concave, later almost plane, smooth, slightly deeper colored than the external surface. *Asci* cylindrical, hyaline, apex rounded, gradually tapering below, operculate, not stained with iodine, 8-spored, 275–320 × 13–17.5 μ. *Ascospores* uniseriate to irregularly biseriate, parallel to obliquely placed, broad-fusoid or spindle-shaped with ends

narrowed and pointed, subhyaline, smooth, 1–3-guttulate, 25.3–33 × 7.8–10 μ. *Paraphyses* filiform, branched or simple, slightly enlarged at the tip, filled with abundant brownish guttules, up to 315 × 3 μ. FIGS. 2, 5, 8.

Collected on soil under oak forest (*Quercus incana* Roxb.): India (Woodstock School, Mussoorie, Aug. 15, 1955, n. 162, TYPE.



FIGS. 4–6. Spores. 4. *Sphaerospora tuberculata*. 5. *Humarina cacaina*. 6. *Humaria mussooriensis*. × 950.

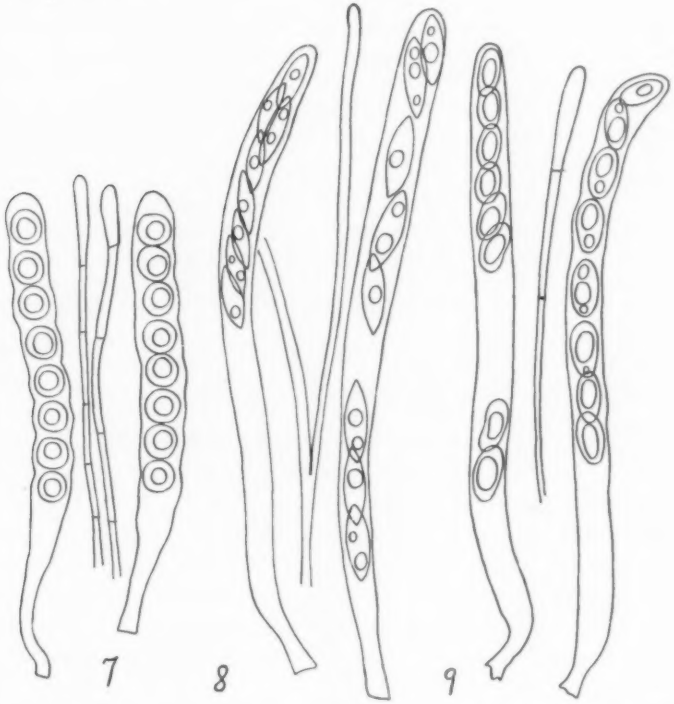
This fungus is characterized by the chocolate brown color of its apothecia and the long, broad-fusoid ascospores; in these two respects it differs from other species of *Humarina*. It is distinct from the species with somewhat similar color in its longer spores and from the species with similarly long spores in its chocolate brown apothecia.

32. **Humaria**[2] **mussooriensis** sp. nov.

Apothecia 5–8 mm in diam., carnosa, cupulata, gregaria vel saepe dense congesta, extus brunnea, pilis fusco-brunneis, rectis, simplicibus, fasciculatis, crasse

[2] Kanouse (Mycologia **39**: 655. 1947) pointed out that *Humaria* is the valid generic name under the International Code of Botanical Nomenclature for the species generally referred to *Lachnea* or *Patella*. This has been accepted by Cash

tunicatis, subacutis, usque 188 × 12 μ vestita, hymenio pallide brunneo; asci cylindrici, ad apices rotundati, breve stipitati, octospori, 225–263 × 13–15.8 μ; ascosporae hyalinae, ellipsoideae, ad apices angustatae, glabrae, uniseriatae, interdum 3-guttulatae, saepius guttula una magna sporam implenti, 17.5–26.3 × 10.5–13 μ; paraphyses 278 × 3 μ, ad apices usque 4 μ inflatae.



FIGS. 7–9. Asci and paraphyses. 7. *Sphaerospora tuberculata*. 8. *Humarina cacaina*. 9. *Humaria mussooriensis*. × 400.

(Mycologia **40**: 724–727. 1948). According to Kanouse the name *Humaria* should be used in the strict sense of Fuckel (Symb. Myc. 1870) and must not be confused with *Humaria* of Saccardo (Syll. Fung. **8**: 118. 1889), which was renamed as *Humarina* by Seaver (Mycologia **19**: 87. 1927).

The name *Lachnea* is invalid since it had previously been used for a genus of flowering plants, as pointed out by Seaver (Mycologia **40**: 498. 1948).

Kanouse (Mycologia **39**: 655. 1947) also pointed out that the name *Patella* Weber, which Seaver selected to avoid the use of *Lachnea*, is also untenable as it is pre-Friesian. Revision of the taxonomy of these species is now in progress by other authors; pending publication of this work, *Humaria* appears to be the preferable generic name.

Apothecia 5–8 mm in diameter, gregarious, often closely crowded together or congested, sessile, cupulate, fleshy, regular, becoming compressed as a result of crowding; external surface brown to dark brown, hairy; hairs brown to deep brown, fascicled, up to 10 hairs in a fascicle, simple, straight, bristle-like, septate, thick-walled, wall up to 3 μ thick, apex rounded to subacute, narrowed toward the base, up to 188 × 12 μ; margin hairy; hymenium concave, smooth, light brown. *Asci* hyaline, cylindrical, apex rounded, narrowed below into a short stem-like base, operculate, not turning blue with iodine, 8-spored, 225–263 × 13–15.8 μ. *Ascospores* uniseriate, parallel to oblique, ends usually overlapping, subhyaline to hyaline, ellipsoid, considerably narrowed at the rounded ends, smooth, mostly uniguttulate, sometimes up to 3-guttulate, single guttule filling about three-fourths of the spore cavity, 17.5–26.3 × 10.5–13 μ. *Paraphyses* hyaline, filiform, slightly enlarged at the tip, simple, septate, up to 278 × 3 μ, reaching a diameter of 4 μ at the tip. *Excipular cells* brown to dark brown, roundish, up to 60 μ in diameter. FIGS. 3, 6, 9.

Collected on soil under coniferous forest: India (Dhanolti, Mussoorie, Aug. 27, 1955, n. 163, TYPE).

No species of *Humaria* has been found which agrees with this Mussoorie fungus in the brown hymenium, fasciculate hairs, and smooth spores of such dimensions. It differs from *Patella gilva* (Boud.) Seaver (North American Cup-Fungi—Operculates. 1928) in its occurrence on ordinary soil, in its fascicled hairs, and in the larger spores containing 1–3 oil drops.

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SOME LEAFSPOT FUNGI ON WESTERN GRAMINEAE. XI[1]

RODERICK SPRAGUE[2]

(WITH 2 FIGURES)

The eleventh article on this series is based on a study of mycological materials obtained in 1955 and 1956. Some of the collections made in the Wallowa Mts., Oregon, in 1955, and which were not discussed in the last paper (**13**), are reported here. Much of this article deals with specimens obtained by G. W. Fischer and the writer in Montana, Wyoming and Idaho during late summer, 1956. Excellent material was found in the Glacier National Park area in particular. Unseasonable snow storms in late August drove us from the high country of Wyoming but some materials of interest were obtained in Yellowstone National Park and adjacent Idaho. Another trip into the Olympic Peninsula, Wash. in 1956 (cf. **13**) yielded some new interesting specimens although conditions were very dry.

Some observing and collecting was done in December 1956 near Phoenix, Arizona, and in the Superstition Mts., but without exception the prolonged drought had prevented formation of even saprophytic molds. There was also nothing of mycological interest on irrigated lawn grasses at Phoenix.

Additional collecting was done in the Cascade Mts. west and north of Wenatchee, Washington, and along the Idaho border near some creeks and beaver ponds in Pend Oreille County, Washington.

Mycosphaerella clallamensis sp. nov.

Maculis linearibus, fulvis, brunneis, margine aureis, peritheciis numerosis, globosis, erumpentibus, brevi-papillatis, brunneis, ostiolatis tardius, 60–70 × 55–75 μ diam., 55–60 μ alt., pseudoparenchymaticis, cellulis globosis v. irregularibus, cellularim quatuor aut quinque; ascis brevibus, clavatis, 20–25 × 6–7 μ; sporulis chlorinis, ellipsoideis, 9–12 × 2–2.5 μ.

Spots linear, tawny brown with yellow borders, perithecia numerous, small, globose, erumpent with a very short nipple-like ostiolar region,

[1] Scientific Paper No. 1612, Washington Agricultural Experiment Stations, Pullman, Washington. Project No. 449.

[2] Pathologist, Washington State College Tree Fruit Experiment Station, Wenatchee.

dark brown, 60–70 × 55–75 μ diam., 55–60 μ tall, tardily ostiolate, pseudoparenchymatous, cells globose to polyhedral, composed of four to five closely packed intertwined layers; asci short, clavate, mostly 20–25 × 6–7 μ (occasionally larger), spores, nearly mature, 9–12 × 2–2.5 μ.

Hab. in living leaves of *Bromus laevipes* Shear along edge of woods at the beach near Clallam Bay, Washington. TYPE: WSP 42322. Legit. R. Sprague and Mary W. Sprague, August 23, 1956.

There are not many known species of *Mycosphaerella* parasitic on Gramineae. *M. clallamensis* is morphologically closest to *M. deschampsiae* Sprague which also produces perithecia during the same season that the living host is invaded (**11**). The perithecia, asci and spores of *M. clallamensis* are all appreciably smaller than *M. deschampsiae*. In addition the former species has yellow ascospores; the latter has hyaline ones.

The type material is relatively abundant. The perithecia are numerous although some are immature (FIG. 2, B). It is hoped that late fall material of *M. clallamensis* will be obtained to further check on spore dimensions. The type material is nearly mature except that the spores themselves may not be quite ripe.

Colletotrichum aquatilis sp. nov.

Maculis fuscis v. fulvis, 15–35 × 3–5 mm diam., acervulis copiosis, obscuris, setis paucis, brunneis; conidiis sub-cultiformibus v. cultiformibus-falcatis, contentu hyalino, pseudomuriculatis, 25–38 × 4.7–8.8 μ.

Spots fuscous to buff but much lighter in the centers, diffuse, 15–35 × 3–5 mm diam., acervuli obscure but sporodochial pads copious, setae brown, few and not prominent, 20–50 μ long, conidia flattened on one side to become sub-cultiform to cultiform-falcate or sometimes club-shaped to stake-shaped, contents hyaline to faintly tinted to weakly chlorinous with a few oil drops scattered in coarsely formed protoplasm which sometimes acquires a falsely muriculate aspect thereby. Spores are notably large for the genus, 25–38 × 4.7–8.8 μ.

Hab. on leaves of the aquatic grass *Catabrosa aquatica* (L.) Beauv. floating, at anchor, in a small creek in the open pine forest about 20 miles north of Burns, Oregon (WSP 20632) (TYPE), July 28, 1950, leg. Sprague and G. W. Fischer; on *C. aquatilis*, Granby, Colorado (WSP 24326), leg. Sprague and Fischer, August 7, 1950, and on *Glyceria pauciflora* Presl growing in water seven miles west of Port Angeles, Washington (WSP 42235), July 23, 1955.

In an earlier paper (**10**) I placed the Oregon and Colorado specimens in *C. graminicola* but mentioned the large size of the spores. The

Oregon type material has spores 28–38 × 5.7–8.8 μ while the Colorado specimen has yellow-hyaline spores 25–30 × 4.7–5.2 μ. *C. graminicola* has spores which average only 18–26 × 3–4 μ while those of *C. falcatum* are larger, 20–27 × 4–5 μ.

Because of the great prevalence of *C. graminicola* and the unusual habitat on floating leaves I decided to credit the abundant water supply as the cause of what I called aberrant spores of *C. graminicola*. When, some years after, I encountered the same fungus on *Glyceria* I re-examined the first two collections. The material on *Glyceria*, while not borne on floating leaves, was producing spores 27–34 × 6.2–7.1 μ almost as large as in the Oregon specimen. This constant large size plus the distinct appearing contents forces us to conclude that the group with large spores belongs in an undescribed species. The name *aquatilis* is derived, obviously, from the habitat. Spores from the type were illustrated in the earlier report (**10**, fig. 1, H).

This discussion should also mention the fact that one earlier report of *Colletotrichum* on *Glyceria* from the Medicine Bow National Forest, Wyoming, was referable rightly to *C. graminicola* proper (**13**). In passing we note the latter species also on *Agrostis tenuis* Sibth. at Sprague Creek, Glacier National Park, Montana (WSP 42760). It is also associated with *Selenophoma* on *Danthonia intermedia* Vasey at Sun Point, Glacier National Park (WSP 42781). The anthracnose causes a reddish to nearly black blotch on this host.

PHYSODERMA GRAMINIS (Büsgen) Fischer was common in brown and yellow stripes on leaves of *Elymus glaucus* Buckl. in brush along the shore of Mary Lake at Sun Point, Glacier National Park, Montana, August 28, 1956 (WSP 42363). There were numerous globose to elliptical amber sporangia, 21–33 × 28–38 μ. The fungus answers to the one discussed by Thirumalacher and Dickson (**17**) and by Childers (**1**; **6**, pp. 12–13). There is no report of this fungus on the genus *Elymus* from the western country.

ERYSIPHE GRAMINIS DC. ex Merát produced conidia and cleistothecia on leaves of *Cinna latifolia* (Trevir) Griseb. along the West Fork of the Wallowa River, Oregon, August 17, 1955 (WSP 42180). Powdery mildew is listed on *C. arundinacea* from Iowa (**6**) but there is no report of mildew on *C. latifolia* from North America. Other new hosts of *Erysiphe* include *Elymus triticoides* Buckl. from Dupuyer, Montana (WSP 42386).

DOTHIDELLA ARISTIDAE (Schw.) Ell. & Ev. was abundant on *Distichlis stricta* (Torr.) Rydb. at Silesia, Montana. This prevalent charspot has apparently not been collected previously on this host in Montana.

DILOPHOSPORA ALOPECURI (Fr.) Fr. caused a head blast of *Calamagrostis rubescens* Buckl. in second growth woods two miles south of Saint Mary, Montana (WSP 42396). Numerous pycnidia containing maturing spores dot the surface of the gray stroma. The only other report of this fungus on *Calamagrostis* is on *C. canadensis* from Wisconsin (**6**). The heads of the Saint Mary material were attacked by *Claviceps purpurea* (Fr.) Tul. (WSP 42395). *D. alopecuri* was found on heads and culms of *Poa nevadensis* Vasey near the hamlet of Reno, Idaho, in the dry semi-desert (WSP 42791).

STAGONOSPORA MARIAE Sprague was described several years ago from living leaves of *Agrostis oregonensis* Vasey. This fungus has multiseptate, coarsely clavulate spores 55–67 × 5–5.3 μ (**10**). In a recent trip to the Olympic Peninsula we found the same fungus several times, twice on *Bromus aleutensis* Trin., once on *B. sitchensis* Trin., and then on *Trisetum cernuum* Trin. The spores ranged from 45–63 × 4.9–5.7 μ. As in the type collection (**10**) there was only slight yellowing in the spores. Most of them were hyaline and not referable to *Phaeoseptoria calamagrostidis* Sprague. Webster recently found the perithecial stage of comparable fungi in England (**18**). He determined that the common mold *Leptosphaeria microscopica* Karst. had as its pycnidial stage *Phaeoseptoria festucae* Sprague (cf. **5**, **6**). While this fungus with its brown spores is readily distinguished from *St. mariae*, another fungus, *Leptosphaeria nigrans* (Desm.) Ces. & De Not. as given in Saccardo **12**: 377, was less readily segregated. This fungus produced a pycnidial stage similar to *Septoria alopecuri* var. *calamagrostidis* Grove. It will be recalled from previous work that we were never able to locate spores of this variety (**5**, **7**) but we concluded from Groves' report that our *Phaeoseptoria calamagrostidis* had much coarser spores than Groves' variety and that it was similar to *P. phalaridis* (Trail) Sprague. Webster's illustration bears this out. Our fungus, *St. mariae*, is different from the pycnidial forms of both *L. microscopica* and *L. nigrans*.

Material used in the recent restudy of *St. mariae* included collections on *Bromus aleutensis* from five miles north of Gettysburg, Washington (WSP 42329) and near Neah Bay, Washington; on *B. sitchensis* at Neelton, Washington (WSP 42334, spores 40–55 × 4.6–5.3 μ) and on *Trisetum cernuum* from the Hoh Indian Reservation, Washington (WSP 42335). The collection on *Trisetum* showed active parasitism by the *Stagonospora*.

STAGONOSPORA SIMPLICIOR Sacc. & Berl. caused an extensive spot and chocolate-purple blotch on *Stipa columbiana* Macoun at Roger's

Pass, Montana (WSP 42360). Although almost omnipresent after summer rains in the Rockies there is no report from Montana. Associated in part of this material were spores similar to *Spermospora subulata* (Sprague) Sprague but repeated mounts of this were examined without clue as to their source.

SEPTORIA MACROPODA var. SEPTULATA (Gz. Frag.) Sprague, a common fungus, was found on an uncommon host, *Poa nervosa* (Hook.) Vasey (cf. **8**), under brush along the road to Hat Point, Wallowa County, Oregon (WSP 42193, 42243), August 16, 1955. Associated are a few plants of *P. canbyi* (Scribn.) Piper also showing spots caused by the *Septoria* (WSP 42248).

SEPTORIA TENELLA Cooke & Ellis produced microspores on *Festuca occidentalis* Hook., near Lake Wallowa along the West Fork of the Wallowa River, Oregon (WSP 42242). The same kind of material on the same host was reported recently from Hurricane Ridge, Olympic National Park (**13**) but the Oregon material had some spores as long as 10–15 μ and rarely as long as 20 μ. The spores were narrow, averaging 0.8–1.2 μ.

A *Phyllosticta* phase of *Septoria tenella* was present in elliptical ashy spots on the forest grass *Festuca subulata* Trin. along War Creek, Okanogan County, Washington (WSP 42733). The spores are bacillar, rarely 1-septate, 8–16 × 0.8–1.3 μ (FIG. 1, A). In the most recent article in this series (**13**) true microspores of *S. tenella* with spores 4.8–6.5 × 0.8–1.2 μ were reported on *F. occidentalis*. We considered them too small for *Phyllosticta* sp. which had been seen several times from Oregon and once from Idaho (**6**, p. 260 and fig. 49, I) with spores 4.5–11 × 1.4–2 μ. The War Creek material is scarcely microsporous (spermatia-like) but is nearly like small immature spores of *S. tenella* as it occurs in the Far West (cf. **6**, fig. 49, J). We have therefore filed the War Creek fragment as *S. tenella*. It should be noted that one of the ashy lesions contained immature perithecial material of probably triseptate spores of *Leptosphaeria* sp. This was filed separately as WSP 42733 with a glass slide mount included. *S. tenella* with well-developed macrospores was seen on *F. idahoensis* Elmer at Hudson Bay Divide, Montana (WSP 42748).

Microspores from small pycnidia on *Poa interior* Rydb. at Roger's Pass, Montana (WSP 42763) measured 2.5–3.7 × 0.5–0.6 μ (FIG. 1, C). We have no record of a microspore stage of *Septoria macropoda* var. *grandis* Sprague (**6**, **8**). Because the spores are not associated with any macrospores there is no clue to their identity. They must be left as *Phyllosticta* sp.

SEPTORIA NODORUM Berk. was found on *Bromus aleutensis* near Neah Bay, Washington (WSP 42330). The young spores are 1-septate, 12–15 × 2.2–2.5 μ borne in an elliptical gray spot on a lone leaf. The fragment compares with some material found on *Festuca subulata* Trin. in Mason County, Washington (**13**).

SEPTORIA AVENAE Frank, the prevalent buff spot on *Glyceria*, was found on *G. elata* (Nash) Hitchc., near Saint Mary, Montana, an unreported host for Montana (WSP 42349; 42758). The same fungus caused tawny lesions on *Trisetum cernuum* in moist woods near Gibbonsville, Idaho, September 2, 1956 (WSP 42399). The spores, which

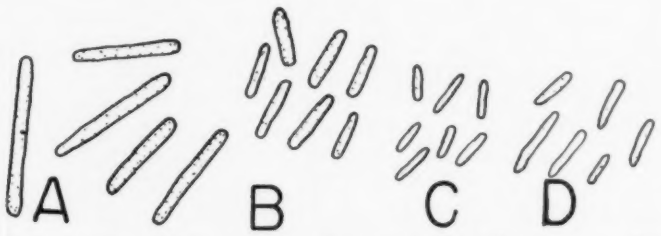

FIG. 1. Leafspot fungi. A. Pycnidiospores of *Septoria tenella* on *Festuca subulata*, War Creek, Okanogan County, Washington (WSP 42733). B. Microspores of *Phleospora idahoensis* on *Festuca occidentalis*, Hudson Bay Divide, Montana (WSP 42726). C. Pycnidiospores (microspores) of *Phyllosticta* sp. on *Poa interior*, Rogers Pass, Montana (WSP 42763). D. Microspores of *Septoria spartinae* on *Spartina gracilis*, Madison River, Yellowstone National Park, Wyoming (WSP 42747). All drawings in Fig. 1 are × 2000, done with the aid of the camera lucida.

measured 35–48 × 2.9–3.5 μ, were typical for the species (cf. Shaw **3, 4**). The host *Trisetum* is unreported and appears also to be resistant. Most of the lesions were sterile and undeveloped. Associated is a small amount of *Puccinia glumarum* (WSP 42672). We also have some material in *Melica spectabilis* Scribn. from the vicinity of Sylvan Pass, Yellowstone National Park, Wyoming, which is identical with *S. avenae*. Most of the western material which we had seen on melics previously has been better assigned to *S. nodorum* (**6, 10, 13**). The 3-septate bacillar spores of the Sylvan Pass collection measured 36–45 × 3–3.5 μ. Our earlier report of *S. melicae* on *M. scabrosa* from Mandan, North Dakota (**7**) is of comparable material. *S. melicae* is doubtfully distinct from *S. avenae* (**6**). *S. avenae* occurs on *Agrostis exarata* Trin. at Kootenai Falls, Montana (WSP 42783).

Septoria avenae and *Stagonospora bromi* Sm. & Ramsb. are not very

different from each other even though listed in different genera. Some material collected on *Bromus sitchensis* Trin. near Port Angeles, Washington, exemplified this situation (WSP 42224). The symptoms on the moldy and rusty leaves (*Puccinia rubigo-vera*) are vague, somewhat mottled, fuscous lesions with only a trace of the black pigment usually associated with lesions of *St. bromi*. The pycnidia are 85–120 μ diameter, globose, brown. They appear to be closer to *S. avenae* than *St. bromi* although the difference is not great. The hyaline 3-septate spores are cylindrical, sometimes sub-cylindrical, scarcely fusiform, 19–29 × 3.3–4 μ. While it seems conservative to call this *St. bromi* (cf. **6**, p. 279, fig. 58, D) it is scarcely distinguishable from *S. avenae* (cf. **6**, p. 221, fig. 27, A). Since there is no opportunity at present for critical life-history studies this seems to be the best classification that can be made now. In another manuscript we report comparable material on *B. ciliatus* from the Olympic Peninsula (**14**).

SEPTORIA AVENAE f. sp. TRITICEA T. Johnson was present on dead leaf tips of *Elymus macounii* (sterile hybrid between *Agropyron trachycaulum* and *Hordeum jubatum*) south of Dupuyer, Montana (WSP 42705). The 1- to 3-septate spores were 32–40 × 3–3.5 μ. The fungus was associated with *Helminthosporium tritici-repentis* Died. and *Puccinia montanensis* Ellis, all apparently new to the west on this hybrid. The injury in all cases was slight, as has been fairly typical on these sterile hybrids.

Agropyron subsecundum (Lk.) Hitchc. is apparently an unreported host of *S. avenae* f. sp. *triticea* from the western area. Material from Gibbonsville, Idaho (WSP 42830) consists of gray-buff lesions on a few leaves. Associated on dried culms of the same plant are obscure pycnidia containing tiny comma-shaped microspores. The pycnidia appear like those of *Selenophoma* as they occur on dried culms but the microspores are more likely a phase of the *Septoria*.

Septoria avenae Frank was found growing with abundant pustules of *Puccinia coronata* Corda on *Phalaris arundinacea* L. ten miles south of Libby, Montana (WSP 42707). The spores are true *S. avenae* in size and shape, 28–35 × 3–3.7 μ and are mature. In the past we have found immature facsimiles of this species on *Phalaris* which have mostly proven to be undeveloped *Stagonospora foliicola* (Bres.) Bubak. Our report of *S. avenae* on *Phalaris* is new to at least the western area.

SEPTORIA ELYMI Ell. & Ev. occurred on a newly reported host, *Elymus hirsutus* Presl, in a forest camp along the Hoh River, Olympic National Park, Washington. It occurs sparingly with abundant material of *Puccinia glumarum* (Schm.) Eriks. and Henn. (WSP 42735).

One spore mount of the *Septoria* is segregated as WSP 42736. The spores are narrow, probably drought-inhibited, 30–43 × 1–1.3 μ.

SEPTORIA SPARTINAE (Trel.) Sprague occurs on gray streaks in living leaves of *Spartina gracilis* Trin. along the Madison River, Yellowstone National Park, Wyoming (WSP 42747). The gray color of the lesions is due to closely and striately arranged deep-seated pycnidia growing in the green, living tissue. The pycnidia are packed with multitudes of tiny spermatia-like microspores, 3–5 × 0.5 μ (FIG. 1, D). We do not recall having seen microspores previously among the few specimens of this little-known species. The *Rhabdospora*-like pycnidia are typical of *S. spartinae*. We see no reason for not recognizing this material as belonging to that species. *S. spartinae* is the only parasitic member of the Sphaeropsidales listed on *S. gracilis* from the West (**15**). The fungus is new to Wyoming. In fact, except for a collection from Utah on this host and one from Iowa and South Dakota on *S. pectinata* Lk. the fungus is unknown from the western region. After reporting this material we found comparable microspore material on *S. gracilis* at Leadore, Idaho (WSP 42818). The plants were heavily rusted with *P. distichlidis* (WSP 42817).

SEPTORIA POLIOMELA Sydow was noted on dried leaves of *Deschampsia caespitosa* (L.) Beauv. at Biscuit Basin, Yellowstone National Park, Wyoming (WSP 42746).

What we have called *Septoria passerinii* Sacc. occurred in small black pycnidia with *Puccinia pattersoniana* Arth. on *Sitanion jubatum* J. G. Sm. at Lost Trail Pass, Montana-Idaho line (WSP 42849). The slightly tinted spores are 0- to 1-septate, cylindrical, straight or curved, thickest in the center, 17–24 × 2.2–3.5 μ. The same fungus was collected on *Sitanion hystrix* from Mt. Hood, Oregon (**6**, fig. 44, E). Most of the spores in the fragment from Lost Trail Pass resemble the one illustrated above the letter E in fig. 44, E above cited. Until better material is available we will leave these fragments in *S. passerinii*.

ASCOCHYTA SORGHI Sacc. was found on *Agrostis scabra* var. *geminata* (Trin.) Swallen in the meadows along the upper portion of the West Fork of the Wallowa River, Oregon (WSP 42240). The pycnidia, which were found on dried basal leaves, contained non-septate to faintly 1-septate spores 12–15 × 2.8–3.2 μ.

ASCOCHYTA UTAHENSIS Sprague occurs on dried leaves of living plants of *Agropyron spicatum* (Pursh) Scribn. & Sm. in Imnaha Canyon towards Hat Point, Wallowa County, Oregon (WSP 42247). The spores were mostly 28–29 × 10 μ, a few as much as 35 × 11 μ. A few of the spores had acentric septations. The fungus is new to Oregon.

As further proof of the wider range of the species than the specific name indicates we have specimens from 10 miles north of Kiowa, Montana, collected August 28, 1956 (WSP 42377). The host in that case is a sterile hybrid between, possibly, *Agropyron spicatum* and *Elymus glaucus*. The heads of the host are reddish-purple, as much as 17 cm long, very narrow, interrupted, awned, *Agropyron*-like and sterile. The host has slight resemblance to the sterile hybrid *Elymus macounii*. The *Ascochyta* had spores 27–30 × 7–10 μ. We also found the fungus on *Agropyron spicatum* proper growing near the hybrid (WSP 42723).

The "black-stem" or microspore phase of *Phleospora idahoensis* Sprague (**6**; **10**, p. 565) has not been illustrated. Drawings are included in this paper (FIG. 1, B) representing the *Phoma* or microspore stage of the fungus. These are from tiny pycnidia on the blackened culms of *Festuca occidentalis* Hook. found at the edge of dry thickets on Hudson Bay Divide south of Saint Mary, Montana (WSP 42726). The microspore phase appears to develop under relatively dry conditions or at the end of short periods of moisture. A small quantity of *P. idahoensis* was seen on *F. idahoensis* growing near the same fungus on *F. occidentalis* (WSP 42749).

The key to species and varieties of *Selenophoma* on Gramineae in an earlier publication (**16**, p. 40) has an unfortunate typographical error in it. It lay undetected until H. C. Greene in recent correspondence complained to the writer about the vagueness of the key in one place. The spores for *Sel. everhartii* are given as 11–"25" × 1.3–2.2 μ. This should read 11–15 × 1.3–2.2 μ. A corrected key for the group follows:

A. Spores sub-acute to acute at both ends.
  a. Spores lunate but often boomerang shape, chiefly 18–30 × 2–4 μ..1. *Sel. donacis*
  b. Spores smaller, less often boomerang shape, chiefly 11–20 × 1.5–2.5 μ. .....2. *Sel. donacis* var. *stomaticola*
  c. Spores relatively long and narrow, rare, chiefly 20–34 × 1.8–2.5 μ..... .....3. *Sel. donacis* var. *linearis*
  d. Spores mostly lunate to arcuate, short, mostly 11–15 × 1.3–2.2 μ..... .....4. *Sel. everhartii*
  e. Spores falcate, wider, chiefly 17–25 × 2–3.2 μ.....5. *Sel. bromigena*
B. Spores obtuse at both ends, mostly 13–17 × 2.5–4.2 μ.....6. *Sel. obtusa*

We continue to find *Selenophoma* on more and more hosts. The head- and stem-speckle symptoms were prevalent on many hosts in Montana following summer rains. The same hosts in the Yellowstone National Park area in Wyoming where the weather had been drier were often free from infection.

SELENOPHOMA DONACIS var. STOMATICOLA (Baüml.) Sprague & A. G. Johnson occurs abundantly on bleached heads and seed stalks of

Danthonia intermedia Vasey in an exposed area on Roger's Pass, Montana. The beautifully lunate, slender spores average 16–21 × 1.7–2.2 μ (WSP 42357). This specimen belongs in Group One of the var. *stomaticola* complex. Similar material was found at Sun Point, Glacier National Park, Montana, on the same host (WSP 42781). It is abundant in western Oregon but occurs scatteringly on mountain species of *Danthonia* in the West. Material on *Festuca occidentalis* Hook. at Hudson Bay Divide, Montana (WSP 42727) and at Yakt Camp, Thompson Lake, Montana (WSP 42757) belongs to Group Three (**16**, p. 24) of the variety *stomaticola*.

A *Selenophoma* referable to *Sel. donacis* var. *stomaticola* occurs on a hybrid *Poa* collection from Roger's Pass, Montana (WSP 42764). The creeping grass appears to be a hybrid between *Poa pratensis* and possibly *P. secunda;* at least the seed is crisp-puberulent as in Section Scabrellae of Gramineae. A trace of var. *stomaticola* was also noted on *Poa interior* Rydb. associated with the hybrid.

SELENPHOMA DONACIS (Pass.) Sprague & A. G. Johnson occurs on *Poa palustris* L. at Roger's Pass, Montana (WSP 42372); on *Agropyron repens* (L.) Beauv. south of Darby, Montana (WSP 42846); on *A. cristatum* (L.) Gaertn. near Dupuyer, Montana (WSP 42392); on *A. desertorum* mixed in with the crested wheatgrass at the same place (WSP 42772), and on smut-infested plants of *Elymus macounii* Vasey near Dupuyer (WSP 42344). The heads of the latter sterile hybrid were particularly long and slender. Most of the material of *E. macounii* which we have seen previously has occurred where *Agropyron trachycaulum* and *Hordeum jubatum* grew in close association. The hybrid material near Dupuyer had *Agropyron inerme* and *Hordeum jubatum* as associates. There is no report of *E. macounii* carrying *Selenophoma*. Perhaps the presence of *Ustilago bullata* Berk. in the heads weakened the otherwise vigorous hybrid sufficiently to permit mild infection by the *Selenophoma*. The smut, new to Montana on this host, is filed as WSP 42343 and referred to G. W. Fischer.

A collection on *Elymus glaucus* at Targhee Pass, Montana (WSP 42743) was assigned to *Sel. donacis* rather than *Sel. obtusa* because the spores were less atypical for the first-mentioned. The fungus was also found on *Stipa columbiana* Macoun at Roger's Pass, Montana. There were a few eyespot lesions on the leaves and an abundance of secondary small pycnidia on dried bleached heads and culms (WSP 42709).

SELENPHOMA EVERHARTII (Sacc. & Sydow) Sprague & A. G. Johnson was collected on a new host, *Calamagrostis inexpansa* A. Gray, by Letha Bunn and Dorothy A. Shaw (WSP 42313). The host was

growing in boggy soil above Soda Springs, Chelan County, Washington. The prominent buff, red-bordered lesions contained numerous pycnidia bearing strongly curved spores t10–16 × 1.9–2.8 μ. These represent the largest spores seen of this species but their strongly curved, arcuate shape differentiates them from *Sel. donacis* var. *stomaticola*. *S. everhartii* also occurs on the heads of *C. montanensis* along Medicine Creek, Montana (WSP 42374) and on *C. rubescens* in Glacier Park, Montana (WSP 42389). We encountered *Sel. everhartii* on *Trisetum cernuum* Trin., a new host, growing along the coast eleven miles east of Neah Bay, Washington (WSP 42332). The spores on the moldy leaves were very small, 10–14 × 1 μ, very strongly curved and borne in tiny pycnidia measuring 50–60 μ diameter. The fungus was associated with *Cladosporium* spp., *Pleospora vagans* Niessl and a pycnidial form resembling the conidial stage of *Pleospora vagans* which has recently been illustrated by Webster (**18**, fig. 4, E). Comparable material of *Sel. everhartii* on *T. cernuum* was found some miles away on the Hoh Indian Reservation, Washington, August 23, 1956 by the writer and Mrs. Sprague (WSP 42337).

SELENOPHOMA OBTUSA Sprague & A. G. Johnson is very common on *Elymus glaucus* Buckl. in the mountains in the Far West but a collection from Saint Mary, Montana, seems to be as far east as it has been found on this host (WSP 42346). The host is also parasitized by the locally abundant *Rhynchosporium secalis* (Oud.) J. J. Davis. The same scald fungus also occurs on *E. glaucus* at Roger's Pass, Montana (WSP 42348). *Sel. obtusa* also occurs on *Sitanion hystrix* (Nutt.) J. G. Smith at Craig Pass, Yellowstone National Park, Wyoming. The spores approach those of *Sel. donacis* var. *stomaticola* (WSP 42718). The fungus, *Sel. obtusa*, occurs on *Agropyron riparium* Scribn. and Smith at Sun Point, Glacier National Park, Montana (WSP 42750). This is a new recognized host for the species.

SELENOPHOMA BROMIGENA (Sacc.) Sprague & A. G. Johnson occurred on dried heads of *Bromus* sp. at Wolf Creek, Montana (WSP 42349) and on leaves of *Bromus carinatus* ten miles north of Kiowa, Montana (WSP 42771).

GLOEOSPORIUM MEINERSII Sprague caused buff streaks on *Phleum pratense* L. along the West Fork of the Wallowa River, Oregon (WSP 42250) and occurred in light buff elliptical spots on long streaks on the same host along the shore of Mary Lake near Sun Point, Glacier Park, Montana (WSP 42775).

HELMINTHOSPORIUM AVENAE Eidam caused a head mold of *Avena fatua* L. south of Dupuyer, Montana (WSP 42381). There is an

earlier report of the fungus on wild oats from Oregon (6). *H. avenae* also occurs in tawny streaks on leaves of *Calamagristis neglecta* (Ehr.) Gaertn. near St. Mary, Montana (WSP 42787). It was associated in part with *Ustilago striiformis* (West.) Niessl; the specimen concerned (WSP 42786) has been referred to G. W. Fischer.

HELMINTHOSPORIUM DICTYOIDES Drechsl. is unreported on *Festuca elatior* L. from Montana. It was found at Big Timber on August 30, 1956 (WSP 42844).

A pale buff to tawny streak on *Cinna latifolia* (Trevir.) Griseb. in a woods two miles south of Saint Mary, Montana (WSP 42777) appears to be caused by *Fusarium nivale* (Fr.) Ces. The numerous spores are without evident heels, somewhat curved to nearly straight, 9–12 × 2.4–2.8 μ. The spores are too narrow for *Gloeosporium meinersii* which otherwise is very similar to this material. *F. nivale* was also present in a scald and eyespot on blossoming plants of *Poa gracillima* Vasey on Logan Pass, Glacier National Park, Montana (WSP 42779).

HETEROSPORIUM AVENAE Oud. has been found from time to time on *Elymus cinereus* Scribn. and Merr. Recently another collection was made at Leadore, Idaho (WSP 42815). The lesions are brown and thickly covered with conidiophores and conidia. The fungus may be secondary but is often associated with definite lesions. The same fungus was also seen on a sterile hybrid, *Elymus cinereus* × *Hordeum jubatum* var. *caespitosum* at Leadore, Idaho (WSP 42820). Small, mostly sterile, pycnidia were also seen. They rarely contained a few *Phoma*-like spores. This is probably an aborted phase of *Septoria infuscans* on this abnormal host. The *Septoria* fungus, abundantly fruiting, was common, as usual, on *E. cinereus* growing with the hybrid.

OVULARIA PUSILLA (Ung.) Sacc. & D. Sacc. was common on *Calamagrostis rubescens* Scribn. on the West Fork of the Wallowa River, Oregon at the lower falls, collected August 16, 1955 (WSP 42186). There were very few spores present. In fact, in over a dozen mounts we saw spores in three. They were definitely muriculate and tended to be strongly elliptical-ovate. The lesions were round to elliptical with white centers and could be confused with the more widespread ones of *Selenophoma everhartii* were it not for the absence of pycnidia. There are no reports of *O. pusilla* on this host, although we believe that we have discarded material of it from time to time as being sterile.

Additional material on this host was found along Hurricane Creek, Wallowa County, Oregon, August 17, 1955 (WSP 42252). *O. pusilla* is also common on this host in woods at Targhee Pass, Montana (and Idaho) (WSP 42809). The fungus was abundant on *C. canadensis* L.

along Breckensdorfer Creek, Pend Oreille County, Washington (WSP 42308); on *C. inexpansa* A. Gray at Sun Point, Glacier National Park, Montana in elliptical red-bordered eyespots (WSP 42696) and on *Calamagrostis montanensis* Scribn. at Roger's Pass, Montana (WSP 42366).

The fungus was common on *Festuca rubra* along the beach five miles north of Gettysburg, Washington, August 22, 1956 (WSP 42320). The lesions on small filiform leaves were dark brown. Only a few spores were seen. This is apparently an unreported host which has escaped notice because of the very obscure symptoms. The fungus was also common on *Agrostis tenuis* var. *aristata* (Parnell) Druce along the beach at Neah Bay, Washington (WSP 42331). The host is an awned, presumably native form of Astoria bent. The fungus was also extremely prevalent on *Agrostis alba* L. near McDonald Lake, Glacier National Park, Montana (WSP 42715) and at Sun Point (WSP 42309). The fungus caused tawny or buff red-bordered eyespots on the bent grasses. It was present on *Agrostis tenuis* Sibth. at Sprague Creek, Glacier National Park (WSP 42759).

Ovularia pusilla caused elongate-elliptical gray spots with yellow borders on *Bromus aleutensis* Trin. ex Griseb. five miles north of Gettysburg, Washington (WSP 42328). The same fungus was found in young elliptical gray lesions on *Bromus carinatus* at McDonald Creek, Glacier National Park (WSP 42339) and on *B. vulgaris* (Hook.) Shear at the same place (WSP) 42766). The spots on *B. vulgaris* were elliptical, ashy colored with associated yellowed leaf areas. Some lesions were as much as 12 × 5 mm in size. It was common but obscure on *Koeleria cristata* in the hills near Fishing Bridge, Yellowstone Park, Wyoming (WSP 42355).

O. pusilla occurs on *Agropyron subsecundum* (Lk.) Hitchc. along Hurricane Creek, Wallowa County, Oregon (WSP 42184). The circular lesions were brown-bordered. *O. pusilla* occurs on *Trisetum canescens* Buckl. in a small meadow at Field Springs Forest Camp, Asotin County, Washington (WSP 42244). The fungus produced eyespot lesions on this host. It also caused comparable symptoms on *Poa canbyi* (Scribn.) Piper north of Kiowa, Montana (WSP 42367). There was a trace of *Ovularia* on *Sitanion hanseni* (*Elymus glaucus* × *Sitanion hystrix*) at Roger's Pass, Montana. The sterile hybrid appeared to be resistant to the locally prevalent rust and leafspot fungi. *O. pusilla* caused elliptical umber spots on *Festuca elatior* L. along an irrigation ditch near McLeod, Montana (WSP 42843).

SEPTOGLOEUM OXYSPORUM Sacc., Bomm. & Rouss. was common on

leaves of *Agrostis scabra* Willd. at the mouth of War Creek, Okanogan County, Washington (WSP 42732). A trace of it was found on *Agropyron trachycaulum* along Highway 14 at Bald Mt., Big Horn Mts., Wyoming (WSP 42836).

Several years ago we reported *Septogloeum oxysporum* as prevalent on *Alopecurus alpinus* J. E. Smith in a meadow near the Targhee Forest

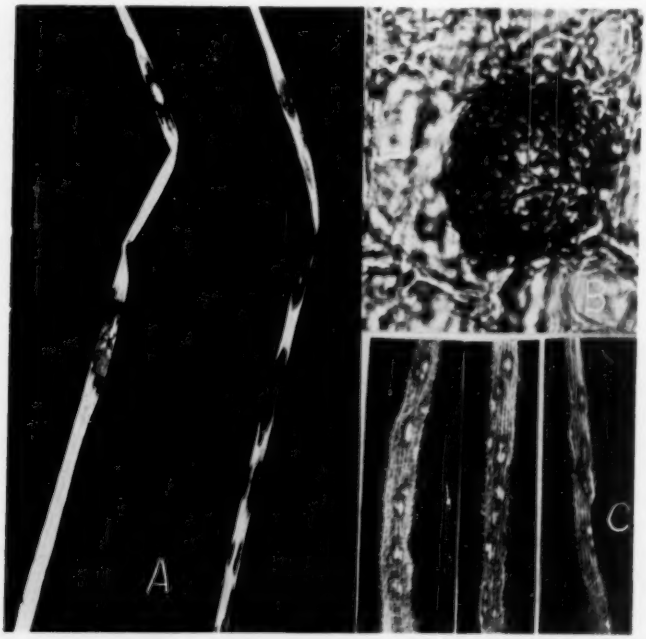

FIG. 2. Leafspot fungi. A. *Septoglocum oxysporum* on leaves of *Alopecurus alpinus*, Targhee Forest Camp, Idaho (WSP 42737). × ⅔. B. Perithecium from type of *Mycosphaerella clallamensis* (WSP 42322). × 697. C. Lesions caused by *Spermospora subulata* on *Trisetum spicatum*, Glacier National Park, Montana (WSP 52765). × 2. Photos in Fig. 2 done by Peggybeth Figaro.

Camp, Idaho (**10**, p. 564–565). Since the symptoms on this host are particularly sharp, an illustration (FIG. 2, A) is included of some new material obtained from the Targhee area in September 1956 (WSP 42737). In the few years since our last visit brush had partially overgrown the swamp. The once lush stand of *A. alpinus* was falling prey to a smut and to this char spot.

A specimen sent by C. T. Rogerson (Kansas State College ex. Mycol. Herb. R. 3782) shows GLOEOCERCOSPORA SORGHI D. Bain & Edg. on living leaves of *Cynodon dactylon* (L.) Pers. The specimen was collected by Henry Wolfe at Hutchinson, Kansas, June 5, 1956. The portion sent by Rogerson is filed as WSP 42832. The narrow lesions on the small leaves of this host are drab with much darker borders. Where prevalent, the entire leaf tends to become buff.

The lesions caused by *Spermospora subulata* (Sprague) Sprague on *Trisetum spicatum* are illustrated in FIG. 2, C. The material is from Logan Pass, Glacier National Park, Montana collected August 28, 1956 (WSP 42765). Fischer collected the same fungus on this host from Logan Pass several years ago (**9**). There are no previous illustrations of symptoms caused by this species of *Spermospora*.

SCOLECOTRICHUM GRAMINIS Fckl. was found on dead basal leaves of *Agrostis variabilis* Rydb. in a meadow above Douglas Lake, Wallowa Mts., Oregon (WSP 42182). The perithecial stage had started to form under the conidiophore tufts. Only a few conidia were left. The host is unreported as harboring parasitic fungi (cf. **2**, **6**, **15**). However, since determination of this collection we have encountered another fungus, *Septogloeum oxysporum* Sacc., Bomm. & Rouss. on the same host from Sylvan Pass in Yellowstone National Park, Wyoming (WSP 42688). *Sc. graminis* is common on *Sitanion hystrix*. Record of it on this host from Prince Creek, Chelan Mts., Washington, is listed only to complete the range (WSP 42316) as is the report on *Poa canbyi* (Scribn.) Piper from Targhee Pass, Idaho (WSP 42739).

HETEROSPORIUM PHLEI Gregory almost defoliated *Phleum pratense* L. in thickets along the shore of Mary Lake near Sun Point, Glacier National Park, Montana (WSP 42700). As usual, very few conidiophores or conidia were present on the eyespot lesions. Associated was a blotch caused by *Gloeosporium meinersii* Sprague which produced spores in great numbers in contrast to the paucity of those of the *Heterosporium*. There were also a few leaves bearing large numbers of sporulating pycnidia of *Selenophoma donacis* var. *stomaticola*. All three fungi are newly reported from Montana on this host.

MASTIGOSPORIUM RUBRICOSUM (Dearn. & Barth.) Nannf. was found on *Calamagrostis rubescens* Buckl. near Sun Point, Glacier National Park, Montana, August 28, 1956 (WSP 42724). This is the type area for *Fusoma rubricosa* Dearn. & Barth. from which *M. rubricosum* is derived. Nevertheless *C. rubescens* is unreported as a host for this fungus.

HELMINTHOSPORIUM STENACRUM Drechsl. was common on lower

leaves of *Agrostis scabra* Willd. along War Creek, Okanogan County, Washington (WSP 42734). The spores averaged 75–86 × 14–17 μ on scattered conidiophores.

RHYNCHOSPORIUM SECALIS (Oud.) J. J. Davis on *Elymus glaucus* Buckl. at relatively high and exposed locations, such as at Logan Pass, Montana, shows wide diversity in spore shape (WSP 42751). The spores vary from relatively typical hooked ones to cylindrical forms like *R. orthosporum* Caldwell and aberrant distorted ones resembling neither. This condition is not uncommon in the western mountains.

SCLEROTIUM RHIZODES Auersw. was abundant on *Agrostis* and *Calamagrostis* spp. in Yellowstone Park, Wyoming and west into Idaho. New records include it on *Calamagrostis canadensis* var. *scabra* (Presl) Hitchc. from three places in Wyoming (WSP 42678; 42692). It was particularly common near Fishing Bridge, Yellowstone Park and at Targhee Pass on the Montana-Idaho border (WSP 42840) and at Sun Point, Glacier National Park, Montana (WSP 42725).

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A REVISION OF THE NORTH AMERICAN SPECIES OF CHLOROCIBORIA (SCLEROTINIACEAE) [1]

C. S. Ramamurthi,[2] Richard P. Korf,[3] and Lekh R. Batra [4]

(with 4 figures)

The value of using sectioned material for the identification of Inoperculate Discomycetes can hardly be overemphasized. In the present study sections cut with a hand razor have greatly facilitated distinguishing—in two cases—species of *Chlorociboria* that have been regularly confused.

The genus *Chlorociboria* Seaver was erected in 1936 with the holotype species *C. aeruginosa* and two additional species, *C. versiformis* and *C. strobilina*. The first two species had been treated earlier by most authors as members of the genus *Chlorosplenium* Fr., based on *C. chlora* (Schw.) Curt. *in* Sprague, but this genus resembles *Chlorociboria* only in possessing greenish-colored apothecia and is quite distinct in apothecial structure. When the genus *Chlorociboria* was erected, however, Seaver (**1936**) failed to provide a Latin diagnosis and this is still lacking. According to the present International Code of Botanical Nomenclature (Lanjouw **1956**: Art. 34, 42) not only the generic name *Chlorociboria*, but also the various combinations in the genus provided by Seaver (**1936**), by Kanouse (**1947**), and by Dennis (**1956**) are technically *nomina nuda* since combinations are not validly published until the genus is validly published. On the basis of our

[1] The authors wish to express their appreciation to Dr. D. P. Rogers, New York Botanical Garden, for preparation of the Latin diagnosis and for the loan of certain specimens, and to the curators and directors of the following herbaria for the loan of type and authentic specimens: New York State Museum, Albany (S. J. Smith); National Fungus Collections, Beltsville (J. A. Stevenson); Botanical Museum, Helsinki (A. Kalela and N. Malmström); Rijksherbarium, Leiden (R. A. Maas Geesteranus); Academy of Natural Sciences, Philadelphia (C. E. Smith, Jr.); Naturhistoriska Riksmuseum, Stockholm (S. Ahlner).

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studies, we believe the genus is an excellent one, and provide a Latin diagnosis which will validate the generic name. The new combinations which are necessary are made in the name of those workers who first (invalidly) proposed them.

White (**1941**), Kanouse (**1947**), Buchwald (**1949**) and Dennis (**1956**) all accept the genus *Chlorociboria*, and would apparently place it in the vicinity of *Ciboria* Fckl. and *Rutstroemia* Karst. emend. Rehm (= *Calycina* Gray emend. Seaver non emend. Kuntze) on the basis of its ciborioid apothecial structure. Although Whetzel (**1945**) did not include the genus in the Sclerotiniaceae, one of us (R. P. K.) feels the limits of that family should be broadened to include *Chlorociboria*, even though an evident stroma is lacking.

Seaver (**1951**) recently emended his concept of the genus by excluding *C. versiformis* and by transferring this species to *Midotis*[5] Fr. While it is a fact that the apothecia of this species are often laterally attached, the tissue structure of the apothecium does not resemble *Midotis*. In no species of *Midotis*[6] have we observed the ascus pore to blue in iodine, whereas in *C. versiformis* (and in all other species of *Chlorociboria*) there is a distinct blueing of the pore.

The treatment of *C. strobilina* presented by Seaver (**1951**) is inconsistent. He indicates (p. 99) that *Peziza bulgarioides* Rab. is a synonym of this species, but also states (p. 91) that the genus *Rutstroemia* Karst.[7] was founded on *P. bulgarioides*, and that in his opinion the species belongs in *Midotis*. Perhaps he had intended at one time to transfer this species also to *Midotis*. *C. strobilina* is, on the basis of our study, certainly not a *Midotis*, and seems to us to be closely related to *C. versiformis*. We retain the species in the genus, but on the basis of priority the name becomes *C. bulgarioides*.

Dennis (**1956**) unfortunately included *C. strobilina* in the synonymy of a different species, *Phialea strobilina* (Fr.) Gill., which has narrow spores and a different apothecial structure. We do not believe that the Friesian species treated by Dennis belongs in the genus *Chlorociboria*.

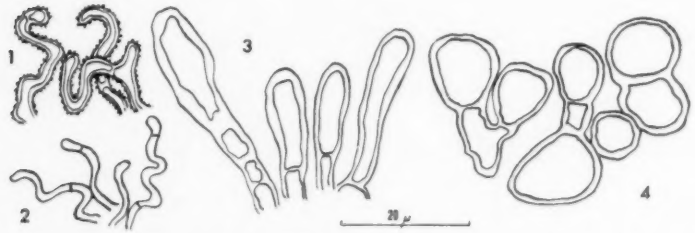
There are two clear-cut groups (perhaps both worthy of generic rank) among the American species of *Chlorociboria*, one with aeruginous-green apothecia on usually greenish-stained wood, the other with

[5] The status of the genus *Midotis* is in serious doubt, as the type species is unknown (cfr. Donk **1957**). For the time being I accept it in the sense of Durand (**1923**). The genus *Ionomidotis* Durand, which Seaver (**1951**) synonymized with *Midotis*, seems quite distinct (R. P. K.).

[6] Or of *Ionomidotis* (R. P. K.)

[7] But certainly not in the sense of White (**1941**) (R. P. K.).

olive-green apothecia on unstained wood or *Picea* cones. Under certain conditions of drying, apothecia of the second group may also develop aeruginous tints. *Chlorosplenium aeruginosum* is the name commonly applied to the aeruginous specimens. In the European literature, two species, *C. aeruginosum* and *C. aeruginascens,* have long been distinguished. The existing descriptions of these two species read almost identically, except for the fact that the spores of the latter are given as appreciably shorter than those of the former. Kanouse (**1947**) is one of the American authors who has recognized both species; she has transferred *C. aeruginascens* to *Chlorociboria.* Neither Seaver (**1936, 1951**) nor Dennis (**1956**) has recognized any difference between these species, and have synonymized them. On the basis of our present studies, we



FIGS. 1–4. Camera lucida drawings of the tomentum hyphae and excipular cells of species of *Chlorociboria,* drawn at × 2150 and reduced in printing to × 1000. 1. *C. aeruginosum* (CUP *37290*). 2. *C. aeruginascens* (R. P. K. *1514*). 3. *C. versiformis* (CUP *27831*). 4. *C. rugipes* (R. P. K. *2461*).

find that these two species are easily distinguishable, particularly on sectioning the apothecia. In *Chlorociboria aeruginosa* we find not only much larger spores, but highly diagnostic tomentum hyphae which are strongly roughened with crystals (FIG. 1). In *C. aeruginascens,* on the other hand, the spores are not only smaller but the tomentum hyphae (which are more scanty) are completely smooth (FIG. 2).

In the group with olive-green apothecia, *C. strobilina* is easily distinguishable on the basis of substrate (*Picea* cones). The rather large, often laterally attached form on wood is known in the literature as *C. versiformis.* One of us (R. P. K.) had noted both short- and long-spored forms in his collections, and therefore a critical study of collections under this name was undertaken as a special problem by another of us (C. S. R.). Transverse sections of apothecia revealed that there are two fungi passing under this name. In the true *C. versi-*

formis, the spores are longer (though there is not as sharp a discontinuity in spore size as there is between the aeruginous-green species), and the ectal excipulum consists of filamentous cells (FIG. 3). In the other species, macroscopically almost indistinguishable, the ectal excipulum is composed of subglobose cells (FIG. 4); we have found that the type specimen of *Helotium rugipes* Peck matches this second species, and propose a transfer of that species to the genus *Chlorociboria*.

The following key, developed on the basis of these studies, is likely to prove helpful in the identification of the North American species of the genus. We have included a single European species that should be sought in this country.

Chlorociboria Seaver, gen. nov.

≡ *Chlorociboria* Seaver, Mycologia **28**: 390, 391. 1936, *nomen nudum*.

Apothecia stipitata vel substipitata, frequenter lateraliter alligata, < 1 cm (rara 2 cm) diam., structura *Ciboriae* similia sed colore aeruginea vel olivaceo-viridia; ascis octosporis, inoperculatis, poro liquore iodi cyanescente; ascosporae ellipsoideae, allantoideae, cylindraceae, vel interdum fusiformes, hyalinae, aseptatae, frequenter biguttulatae et species pseudoseptatae; paraphyses filiformes, subclavatae. HOLOTYPUS: *Helvella aeruginosa* Oed.

KEY TO THE NORTH AMERICAN SPECIES OF CHLOROCIBORIA

I. Apothecia aeruginous-green.

A. Apothecia on wood, part of which at least is stained greenish by the mycelium.

1. Ectal excipulum giving rise to few, hair-like, straight or sometimes coiled, *smooth* hyphae that form a delicate tomentum; apothecia usually laterally attached, often > 5 mm diam., collapsing laterally and becoming inrolled on drying; stipe usually > 3 mm long; spores (4.2–)5–8(–9.8) × 0.7–2.8 μ (means of collections 5.9–7 × 1.4–2 μ) ..... 1. *C. aeruginascens*

2. Ectal excipulum giving rise to numerous, hair-like, straight or often coiled, *strongly roughened* hyphae that form a tomentum; apothecia usually centrally attached and nearly circular in outline, usually < 4 mm diam., sometimes collapsing but often retaining a definite cupulate shape on drying; stipe < 3 mm long; spores (7–)9–13(–15.4) × 1.4–2.8 μ (means of collections 9.8–12.6 × 1.4–2.8 μ) ... . 2. *C. aeruginosa*

[B. Apothecia on the stems of *Filipendula* (*Spiraea*) *ulmaria*; spores 7–10 × 2–3 μ sec. Dennis (**1956**); not yet known from North America. ..... 3. *C. aeruginella*]

II. Apothecia olive-green; substrate not stained greenish.
C. Apothecia on wood.
3. Ectal excipulum of *subglobose* cells 8–12 μ diam.; medullary excipulum of dark-walled hyphae; spores irregularly ellipsoid, (5.6–)7–9.8(–12) × (2.1–)2.8–3.6(–4.2) μ (means of collections 7.8–9.5 × 2.8–3.6 μ).....4. *C. rugipes*
4. Ectal excipulum of *filamentous*, slightly clavate hyphae oriented nearly perpendicularly to the outside surface of the apothecium, 5–7 μ broad apically; medullary excipulum of hyaline to light-brown hyphae; spores cylindrical to allantoid or fusiform, often pseudo-septate, (7–)9–15(–15.4) × 2.1–3.5 μ (means of collections 11.5–12.9 × 2.1–3.5 μ).....5. *C. versiformis*
D. Apothecia on the cones of *Picea;* spores nearly ellipsoid, 7–9 × 3–4 μ.
.....6. *C. bulgarioides*

TAXONOMIC NOTES

The authors have examined a large number of specimens of most of the species of the genus. Only the critical (authentic, type, etc.) specimens are listed below, together with the exsiccati specimens which have been examined. Since this study was performed primarily on herbarium specimens, no comments are provided here regarding the imperfect states reported for the first two species, though studies of these have been initiated.

1. **Chlorociboria aeruginascens** (Nyl.) Kanouse, comb. nov. (≡ *Peziza aeruginascens* Nyl., Not. Soc. Fauna Fl. Fenn. **10**: 42. 1869; ≡ *Chlorociboria aeruginascens* (Nyl.) Kanouse, Mycologia **39**: 641. 1947, *nomen nudum.*)

Some authors (*e.g.*, Seaver **1936, 1951**; Velenovský **1934**) spell the specific epithet "aeruginescens." Seaver (**1936, 1951**) and Dennis (**1956**) both incorrectly synonymize this species with *C. aeruginosa.* The latter also cites *Chlorosplenium puiggarii* Speg. as a synonym of *C. aeruginosa,* but judging by spore measurements in the literature it is more likely a synonym of *C. aeruginascens* if not distinct. We have not studied Spegazzini's type. Nor have we seen the type specimen of *Peziza aeruginea* Berk., which may provide an older name for this species. Known distribution: Europe, North America and Asia.

Critical specimens examined: *Finland:* Karsten, *Saukkoniemi,* 25 Sept. 1869, H.; *Europe:* Persoon Herb., L. 910.261–154 (as *Peziza aeruginosa*).

Exsiccati specimens examined: Jaczewski, Komarow & Tranzschel, Fungi Rossiae Exs. *194* (*Chlorosplenium aeruginascens*) CUP–D; Korf, Discomyceteae Exs., Fasc. 4 (in preparation); Rehm, Ascom. *408* (*Chlorosplenium aeruginascens*) CUP–D; Smarods, Fungi Latvici

Exs. *771* (*Chlorosplenium aeruginosum*) CUP; Wilson & Seaver, Ascom. and Lower Fungi *78* (*Chlorosplenium aeruginosum*) CUP-D.

2. **Chlorociboria aeruginosa** (Oed. ex Gray) Seaver, comb. nov. (≡ *Helotium aeruginosum* Oed. ex Gray, Nat. Arr. Br. Pl. **1**: 661. 1821; ≡ *Chlorociboria aeruginosa* (Oed.) Seaver, Mycologia **28**: 391. 1936, *nomen nudum*.)

The various names based on *Peziza aeruginascens* Nyl. should be removed from the synonymy given by Seaver (**1951**) and by Dennis (**1956**). Additional doubtful synonyms given by Seaver include *? Cantharellus viridis* Schw. (≡ *Chlorosplenium viride* (Schw.) Morg.) for which we have been unable to locate a type specimen, and *? Peziza chlorascens* Schw., which from an examination of the type specimen proves not to be a synonym but a member of the Dermateaceae.

We examined only a single specimen from the Persoon Herbarium under this name, and it proved to be *C. aeruginascens*. A lectotype specimen should be chosen for this species, but a specimen which matches the European concept of the species (*i.e.*, long-spored and with roughened tomentum hyphae) should be selected. The Persoon specimen would be a poor choice for a lectotype, as it would upset the established nomenclature.

Known distribution: Europe, North America and Asia.

Exsiccati specimens examined: Ellis, N. Am. Fungi *987* (*Chlorosplenium aeruginosum*) CUP-A; Korf, Discomyceteae Exs., Fasc. 4 (in preparation); Ravenel, Fungi Carol. **5**: *40* (*Peziza aeruginosa*) CUP-D; Rehm, Ascom. *409b* (*Chlorosplenium aeruginosum*) CUP-D; Roumeguère, Fungi Gallici Exs. *1858* (*Chlorosplenium aeruginosum*) CUP; Roumeguère, Fungi Selecti Exs. *5522* (*Chlorosplenium aeruginosum*) CUP-D. [Smarods, Fungi Latvici Exs. *771* and Wilson & Seaver, Ascom. and Lower Fungi *78*, issued as *Chlorosplenium aeruginosum*, are *Chlorociboria aeruginascens*.]

3. **Chlorociboria aeruginella** (Karst.) Dennis, comb. nov. (≡ *Helotium aeruginellum* Karst., Not. Soc. Fauna Fl. Fenn. **9**: 329. 1868; ≡ *Chlorociboria aeruginella* (Karst.) Dennis, Commonwealth Myc. Inst. Myc. Papers **62**: 48. 1956, *nomen nudum*.)

We have not seen any American material referable to this species, but it would appear to be valid.

4. **Chlorociboria rugipes** (Peck) Ramamurthi & Korf, comb. nov. (≡ *Helotium rugipes* Peck, Ann. Rept. N. Y. State Museum **26**: 82. 1874.)

This species has been regularly confused with *C. versiformis*. *H. rugipes* and *Lanzia rugipes* (Peck) Sacc. as given in Seaver's (**1951**)

treatment of *Midotis versiformis* belong instead in the synonymy of this species. *C. rugipes* appears to be as commonly collected in North America as is *C. versiformis*, since about half of the collections determined as *C. versiformis* which we examined proved to be *C. rugipes*. We have seen no material from Europe or Asia which we would refer to this species, but it may occur there.

Critical specimen examined: *New York:* Peck, *24*, on decayed wood, East Worcester, Otsego County, *July*, NYS, HOLOTYPE of *Helotium rugipes* Pk.

Exsiccati specimen examined: Korf, Discomyceteae Exs., Fasc. 4 (in preparation).

5. **Chlorociboria versiformis** (Pers. ex Pers.) Seaver, comb. nov. (≡ *Peziza versiformis* Pers. ex Pers., Myc. Eur. **1**: 243. 1822; ≡ *Chlorociboria versiformis* (Pers.) Seaver, Mycologia **28**: 393. 1936, *nomen nudum.*)

As indicated under *C. rugipes*, some of the names given by Seaver (**1951**) as synonyms should be removed. Stanley J. Smith, New York State Museum, has kindly called our attention to the type specimen of *Craterellus caespitosus* Peck, Bull. Buffalo Soc. Nat. Sci. **1**: 61. July, 1873, republished in Ann. Rept. N. Y. State Museum **25**: 82. 1873 (later than July), which proves to be a synonym of this species. He has also brought to our attention Peck's statement (N. Y. State Museum Bull. **2**: 48. 1887) that *C. caespitosus* "is a spurious species and is therefore omitted" from a treatment of the species of *Craterellus*. Known distribution: Europe and North America.

Critical specimens examined: *Europe:* Persoon Herb., L. 910.256–1329 (*Peziza versiformis*); Persoon Herb., L. 910.256–1318 (*Peziza versiformis* var.); *New York:* Peck, on old decayed log, *Portville*, Sept., NYS, HOLOTYPE of *Craterellus caespitosus* Pk.

Exsiccati specimens examined: Ellis, N. Am. Fungi *988* (*Chlorosplenium versiforme*) CUP–A; Korf, Discomyceteae Exs., Fasc. 4 (in preparation).

6. **Chlorociboria bulgarioides** (Rab.) Ramamurthi, Korf and Batra, comb. nov. (≡ *Peziza bulgarioides* Rab., Fungi Eur. *1008*. 1866; Hedwigia **6**: 45. 1867; *in* Kalchbrenner, Mathem. Term. Közlemények **5**: 269, pl. 3, f. 4. 1867; descr. ampl. Hedwigia **9**: 136. 1870; = *Chlorociboria strobilina* (A. & S.) Seaver, Mycologia **28**: 39. 1936, *nomen nudum;* N. Am. Cup-Fungi (Inop.), p. 99. 1951, *nomen nudum.*)

The synonymy involved is large, complex, and quite doubtful. One

of us (R. P. K.) has made an attempt to untangle and to verify some of the synonymy given by Seaver (**1936, 1951**) and by Dennis (**1956**).

There are two fungi on the cones of *Picea* which have been commonly confused: 1) *Peziza tuberosa* b. *strobilina* A. & S. ex. Fr. (Syst. Myc. **2**: 58. 1822) with broad spores and a ciborioid apothecial structure and 2) *Peziza strobilina* Fr. (Syst. Myc. **2**: 125. 1822) with narrow spores and a phialioid structure. When Dennis listed *Chlorociboria strobilina* as a synonym of *Phialea strobilina*, he apparently confused the two fungi. The discomycete treated by Dennis is indeed the European concept of *Phialea strobilina* (Fr.) Gill. with spores about 8–10 × 1.5–2 μ, and an ectal excipulum of textura oblita.

Seaver, however, had based his combination on the Albertini and Schweinitz epithet, for a fungus with broad spores (about 6–11 × 3–5 μ) and an ectal excipulum of textura globulosa to textura angularis. Apparently this varietal epithet was not raised to specific rank until after *Peziza bulgarioides* was erected, so that a change in the name of the species from that given by Seaver (**1936, 1951**) is required.

The Albertini and Schweinitz epithet has also, however, been transferred to the genus *Phialea*, so that both fungi appear in the literature as *Ph. strobilina*. The earliest *Ph. strobilina* combination was apparently made in 1879 by Quélet, based on the Albertini and Schweinitz varietal epithet, which he raised to specific rank. The Friesian epithet was later transferred to *Phialea* by Gillet in 1887. In 1889 Saccardo again transferred the Friesian epithet to *Phialea*, apparently convinced that Gillet had transferred the Albertini and Schweinitz epithet, but an examination of Gillet's description leaves little doubt that it was the Friesian species that he had transferred two years earlier.

Peziza strobilina Fr. is considered by Dennis and the authors of this paper to be a true *Phialea*. Since *Ph. strobilina* is preoccupied (for the fungus we are calling *Chlorociboria bulgarioides*), a new name is now required for the true *Phialea* with narrow spores and an ectal excipulum of textura oblita if that species is to remain in the genus. Hence: **Phialea eustrobilina** Korf, nom. nov., ≡ *Peziza strobilina* Fr., Syst. Myc. **2**: 125. 1822; ≡ *Phialea strobilina* (Fr.) Gill., Champ. Fr., Disc. p. 103. 1887; ≡ *Ph. strobilina* (Fr.) Sacc., Syll. Fung. **8**: 256. 1889; non *Ph. strobilina* (Alb. & Schw. ex Fr.) Quél., Bull. Soc. Bot. Fr. **25**: 291. [1879!] 1878; Compte Rendu Assoc. Fr. Av. Sci. **9**: 673, pl. 9, f. 8. 1880.

The oldest *specific* epithet available for the ciborioid species is apparently Rabenhorst's "*bulgarioides*." He validly published *Peziza bulgarioides* on an exsiccati label in 1866, republished it in Hedwigia in

1867, and amplified the description in Hedwigia in 1870. Kalchbrenner also published Rabenhorst's manuscript description of *P. bulgarioides* in 1867 (and credited it to Rabenhorst), but this was erroneously catalogued by Saccardo as *Humaria bulgarioides* Kalchbr. Seaver (**1951**) contributed to the confusion by citing Rehm as the original author of *Peziza bulgarioides* in Rabenhorst's Fungi europaei *1311*. The printed label on that packet does not mention Rehm, however, nor is there any evidence available to us from examination of specimens in the Rehm herbarium that Rehm had identified this material, nor that he had identified the specimen issued earlier by Rabenhorst as Fungi europaei *1008*.

To the synonymy given by Seaver and corrected as indicated above there should be added: *Humaria bulgarioides* (Rab.) Sacc. (ut "Kalchbr."), Syll. Fung. **8**: 149. 1889; *Chlorosplenium bulgarioides* (Rab.) Karst., Not. Soc. Fauna Fl. Fenn. **11**: 233. 1870. The following are probable synonyms which should be added: *Peziza rufo-fusca* Weberb., Pilze Nord-Deutschl. **1**: 7. 1873; *Ciboria rufo-fusca* (Weberb.) Sacc., Syll. Fung. **8**: 203. 1889. Known distribution: Europe and North America.

Critical specimen examined: Rabenhorst, Fungi Eur. *1008*, CUP, ISOTYPE of *Peziza bulgarioides*.

Exsiccati specimens examined: Krypt. Exs. *204* (*Ombrophila strobilina*) CUP–D; Rabenhorst, Fungi Eur. *1008* (*Peziza bulgarioides*) CUP; *Ibid., 1311* (*Peziza bulgarioides*) S; Rehm, Ascom. *1005* (*Ombrophila strobilina*) CUP–D; *Ibid., 1554* (*Ciboria rufo-fusca*) CUP–D; Thümen, Myc. Univ. *1113* (*Chlorosplenium bulgarioides*) CUP–D.

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THE GENUS CUMMINSIELLA

JOHN W. BAXTER[1]

(WITH 6 FIGURES)

The genus *Cumminsiella* was established by Arthur (**1**) to segregate from the genus *Uropyxis* those species having subepidermal spermagonia and aecidioid aecia. The species transferred by Arthur were *Uropyxis texana* (Holw. & Long) Arth., *Uropyxis wootoniana* Arth. and *Uropyxis sanguinea* Arth., the last-named rust being chosen as the type of the new genus. Subsequent to Arthur's publication a new species of *Cumminsiella* was described by Cummins (**2**). In the present paper two additional species are added by the transfer of *Uropyxis antarctica* (Speg.) Lindquist and *Uropyxis stolpiana* (Diet & Neg.) Magn.

Cumminsiella resembles *Puccinia* in having subepidermal spermagonia and aecidioid aecia, but differs in having 2 pores in each cell of the teliospore. The latter character indicates relationship with *Uropyxis*. With regard to spermagonial and aecial characters *Cumminsiella* is distinct from *Uropyxis*, which has subcuticular spermagonia and uredinoid aecia. Paraphysate uredia occur in one of the six known species of *Cumminsiella*. In two of the species sporogenous basal cells are present in the uredia. The urediospores in *Cumminsiella* are relatively thick-walled, with pores in zones or scattered. The urediospore wall bears closely set, conical, sharp-pointed tubercles, a type of sculpturing herein described as verrucose-echinulate. In the teliospore, as pointed out by Magnus (**6**), there is some variability in the position of the pores, particularly in the upper cell, in which one of the pores may be apical.

All six species of *Cumminsiella* known at present occur on the Berberidaceae in North America, South America and Europe. The single species reported from Europe, *Cumminsiella mirabilissima* (Pk.) Nannf.,

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appears to have been introduced relatively recently from its native habitat in North America, according to Wilson (**8**).

CUMMINSIELLA Arth., Bull. Torr. Bot. Club **60**: 475. 1933.

Spermagonia subepidermal, with paraphyses. Aecia subepidermal, aecidioid; aeciospores globoid or ellipsoid; wall hyaline, verrucose. Uredia subepidermal, with or without paraphyses; urediospores obovoid, ellipsoid, pyriform or fusiform; wall yellow or cinnamon-brown, verrucose-echinulate; germ pores zonate or scattered. Telia subepidermal; teliospores 2-celled, oblong, ellipsoid or subfusiform; wall chestnut- or cinnamon-brown, verrucose or striate, germ pores 2 in each cell, variable in position, usually lateral near the septum.

KEY TO THE SPECIES

Teliospores pedicel swelling in water to a width of 12–33 μ.
- Teliospores 40–60 μ long ..... 1. *C. antarctica*
- Teliospores 27–38 μ long ..... 2. *C. stolpiana*

Teliospore pedicel 10 μ or less in width.
- Teliospore pedicel 60 μ or less in length.
  - Urediospore pores zonate ..... 3. *C. texana*
  - Urediospore pores scattered ..... 4. *C. standleyana*
- Teliospore pedicel 120–180 μ long.
  - Teliospores uniformly verrucose ..... 5. *C. mirabilissima*
  - Teliospores longitudinally striate ..... 6. *C. wootoniana*

1. **Cumminsiella antarctica** (Speg.) comb. nov.

Puccinia antarctica Speg., Bol. Acad. Cienc. de Cordoba **11**: 179. 1887.

Uropyxis naumanniana Magn., Ber. Deutsch Bot. Ges. **10**: 320. 1892.

Puccinia naummaniana (Magn.) Neger, Ann. Univ. de Chile **93**: 787. 1896.

Puccinia magellanica Speg., Rev. Chil. de Hist. Nat. **25**: 267. 1921.

Uropyxis antarctica (Speg.) Lindquist, Notas de Museo de La Plata **11**: 372. 1947.

Spermagonia, aecia and uredia unknown. Telia hypophyllous, 0.2–1.0 mm in diameter, scattered, pulverulent, blackish-brown; teliospores narrowly ellipsoid, oblong or fusiform, 15–25 × 40–60 μ, rounded or narrowed at both ends, slightly or not constricted at the septum; wall 2–3(–4) μ thick, uniform, dark chestnut-brown, finely and closely verrucose; pores 2 in each cell, next to the septum; pedicel thick-walled, yellowish next to the spore, hyaline downward, hygroscopic except for

FIG. 1. Teliospores of *Cumminsiella antarctica* (from type), × 800. 2. Teliospores of *C. stolpiana* (from type), × 800. 3. Teliospores of *C. texana* (from type), × 800. 4. Teliospore and urediospore of *C. standleyana* (from type), × 800.

a short portion next to the spore, swelling in water to a width of 15–33 μ, 35–95 μ long.

HOSTS AND DISTRIBUTION: *Berberis buxifolia* Lam., Tierra del Fuego, Argentina.

TYPE SPECIMEN: On *Berberis buxifolia*, Isla de los Estados, New Year Island, 1882, L.P.S. *9001*.

ILLUSTRATIONS: Magnus, Ber. Deutsch. Bot. Ges. **10**: Pl. 19, Figs. 8–12; Spegazzini, Rev. Chil. de Hist. Nat. **25**: Pl. 20, Fig. 1; Lindquist, Notas del Museo de La Plata **11**: p. 378, Fig. 1, B; this paper, FIG. 1 (from type).

Cumminsiella antarctica is distinctive because of the teliospore pedicel, which is inflated except for a short portion next to the spore. The spermagonial, aecial and uredial stages of this rust are unknown. It is here assigned to the genus *Cumminsiella* on the basis of host relationship and teliospore characters.

The name *Puccinia magellanica* was proposed for this species by Spegazzini (**7**) who considered *Aecidium magellanicum* Berk. to be the aecial stage. As pointed out by Lindquist (**5**), there is no evidence to indicate such a connection.

2. **Cumminsiella stolpiana** (Diet. & Neg.) comb. nov.

Uredo stolpiana Magn., Ber. Deutsch. Bot. Ges. **11**: 325. 1892.
Puccinia stolpiana Diet. & Neg., Engl. Bot. Jahrb., **27**: 13. 1899.
Uropyxis stolpiana (Diet. & Neg.) Magn., Ber. Deutsch. Bot. Ges. **27**: 120. 1899.

Spermagonia epiphyllous, subepidermal, globoid, 120–160 μ in diameter, cinnamon-brown. Aecia hypophyllous, aecidioid, in groups up to 2 mm in diameter; peridial cells hexagonal or rectangular in surface view, inner wall 3–4 μ thick, verrucose, outer wall 6–7 μ thick, striate; aeciospores angularly globoid or ellipsoid, 15–19 × 18–25 μ, wall hyaline, 1–1.5 μ thick, finely verrucose. Uredia hypophyllous, 0.2–0.5 mm in diameter, scattered, pulverulent, cinnamon-brown; urediospores obovoid or broadly ellipsoid, 18–22 × 22–30 μ; wall yellow, 2–2.5 μ thick, finely and closely verrucose, pores 7–8, in 2 zones of 3–4 pores each. Telia hypophyllous, 0.3–1 mm in diameter, scattered, pulverulent, blackish-brown; teliospores broadly ellipsoid or oblong, 24–30 × 27–38 μ, rounded at both ends, slightly constricted at the septum; wall 2–3 μ thick, thickened to 3–4(–6) μ at the angles of the septum, dark chestnut-brown, rugose-verrucose; pores 2 in each cell, next to the septum; pedicel thick-walled, brownish next to the spore, hyaline down-

ward, up to 150 μ long, lower portion hygroscopic, expanding in water to a width of 12–24 μ, frequently partially dissolving.

HOSTS AND DISTRIBUTION: *Berberis buxifolia* Lam., Chile.

TYPE SPECIMEN: On *Berberis buxifolia*, Chile, Neger.

ILLUSTRATIONS: FIG. 2 (from type).

The teliospores of *Cumminsiella stolpiana* are much like those of *C. antarctica* in the color and sculpturing of the wall, but differ in being shorter and broader. The pedicel is hygroscopic like that of *C. antarctica*, but is narrower and less sharply defined, usually partially dissolving in water.

The aecial and spermagonial stages described above, although not included in the original description by Dietel and Neger (**3**), are present in the type material and probably belong to this species.

3. CUMMINSIELLA TEXANA (Holw. & Long) Arth., Bull. Torr. Bot. Club **60**: 475. 1933.

Puccinia texana Holw. & Long in Long, Bull. Torr. Bot. Club **29**: 113. 1902.

Uropyxis texana (Holw. & Long) Arth., North Amer. Flora **7**: 155. 1907.

Aecidium butlerianum Rosen & Arth. in Rosen & Kirby, Phytopath. **9**: 572. 1919.

Spermagonia epiphyllous, subepidermal, in groups on purple or brown spots, globoid, cinnamon-brown or yellowish, 90–160 μ in diameter. Aecia hypophyllous, aecidioid, in groups up to 2 mm in diameter on purple or brown spots; peridial cells rectangular or polygonal in surface view, 13–22 × 24–30 μ, hyaline; inner wall about 2 μ thick, verrucose; outer wall 5–7 μ, striate; aeciospores oblong, angularly globoid or ellipsoid, 16–25 × 22–35 μ; wall hyaline or pale yellow, 3–4 μ thick, closely verrucose, occasionally with smooth spots. Uredia hypophyllous, 0.3–0.5 mm in diameter, on angular reddish-brown or dark brown spots, scattered or in groups up to 2 mm in diameter, pulverulent, cinnamon-brown, with peripheral paraphyses and cylindrical basal cells; urediospores globoid, obovoid or broadly ellipsoid, 17–22 × 22–32 μ; wall yellow, 2–3 μ thick, closely echinulate-verrucose, pores 8, in 2 zones of 4 each; paraphyses capitate, clavate or cylindrical, 6–15 × 38–80 μ, continuous or 1–3-septate, arising in fascicles from cylindrical basal cells, wall 1 μ or less in thickness, hyaline or pale yellow. Teliospores in the uredia, ellipsoid, 20–25 × 23–34 μ, rounded at both ends, slightly constricted at the septum; wall 2–3.5 μ, thickened to 3–5 μ and paler over the pores, usually umbonate at the apex, chestnut-

or dark cinnamon-brown, finely and obscurely verrucose, appearing smooth; pores 2 in each cell, lower cell with 2 lateral pores next to the septum, upper cell usually with 1 lateral pore and 1 apical pore capped by a hyaline or yellowish umbo, occasionally with 2 lateral pores; pedicel thin-walled, hyaline, fragile, usually length of spore or shorter, occasionally up to 60 μ long.

HOSTS AND DISTRIBUTION: *Berberis trifoliolata* (Moric.) Fedde, Texas.

TYPE SPECIMEN: On *Berberis trifoliolata*, Austin, Texas, March 17, 1901, Long *44a*.

ILLUSTRATIONS: Long, Bull. Torr. Bot. Club **29**: 113, Fig. 3; Holway, N. Am. Ured., Pl. 4, Fig. 19; this paper, FIG. 3 (from type).

EXSICCATI: Barth. Fungi Columb. *2599* (as *Uropyxis texana*); Barth. N. Am. Ured. *7153* (as *Uropyxis texana*).

Cumminsiella texana differs from the other species of the genus in having paraphysate uredia. The paraphyses are septate, variable in shape and occur in clusters on cylindrical basal cells.

In this species there is considerable variability in the location of the pores in the upper cell of the teliospore. Usually one pore is apical and capped by a conspicuous umbo, while the other is lateral. Occasionally both pores are lateral, in which case the apical umbo is lacking.

4. CUMMINSIELLA STANDLEYANA Cumm., Bull. Torr. Bot. Club **67**: 607. 1940.

Spermagonia epiphyllous, subepidermal, globoid or flask-shaped, 120–170 μ in diameter, cinnamon-brown. Aecia hypophyllous, aecidioid, in groups up to 3 mm in diameter on reddish spots; peridial cells oblong or ellipsoid in surface view, 15–20 × 20–30 μ, inner wall 1–1.5 μ thick, verrucose, outer wall 4–6 μ, smooth or striate; aeciospores globoid or ellipsoid, 11–20 × 13–24 μ; wall hyaline, 1 μ thick, finely verrucose. Uredia hypophyllous, 0.1–0.3 mm in diameter, scattered, pulverulent, cinnamon-brown, with cylindrical basal cells; urediospores obovoid or broadly ellipsoid, 18–23 × 23–29 μ; wall yellow or cinnamon-brown, 2.5–3 μ thick, finely and closely verrucose-echinulate, pores 5–7, scattered. Teliospores in the uredia, oblong or ellipsoid, 20–25 × 30–39 μ, rounded at both ends, constricted at the septum; wall 2–3 μ thick, uniform, cinnamon- or light chestnut-brown, finely and obscurely verrucose, pores 2 in each cell, next to the septum or midway; pedicel thick-walled, hyaline, length of spore or shorter, fragile, usually broken off near the point of attachment.

HOSTS AND DISTRIBUTION: *Berberis fascicularis* (DC.), Guatemala; *Berberis* sp., Guatemala; *Mahonia pinnata* (Lag.) Fedde, Guatemala.

TYPE SPECIMEN: On *Berberis fascicularis*, Volcan de Agua, Dept. Sacatepequez, Guatemala, Feb. 11, 1939, Standley *65222*.

ILLUSTRATIONS: FIG. 4 (from type).

This species is closely related to *C. mirabilissima* but differs in having urediospores with scattered pores and teliospores with shorter, more fragile pedicels.

5. CUMMINSIELLA MIRABILISSIMA (Pk.) Nannf. in Lundell & Nannf., Fungi Exs. Suec. No. **1507a**. 1947.

Uromyces sanguinea Pk., Bot. Gaz. **4**: 128. 1897.
Puccinia mirabilissima Pk., Bot. Gaz. **6**: 226. 1881.
Uropyxis sanguinea Arth., No. Amer. Flora **7**: 155. 1907.
Cumminsiella sanguinea (Arth.) Arth., Bull. Torr. Bot. Club **60**: 475. 1933.

Spermagonia epiphyllous, subepidermal, globoid or flask-shaped, 110–160 μ in diameter, cinnamon-brown or yellowish. Aecia hypophyllous, aecidioid, in groups up to 5 mm in diameter; peridial cells hexagonal or rectangular in surface view, 12–22 × 17–22 μ, inner wall 3 μ thick, verrucose, outer wall 6 μ thick, smooth or obscurely striate; aeciospores angularly globoid, 11–22 × 12–25 μ, wall hyaline, 1–2 μ thick, finely verrucose. Uredia chiefly hypophyllous, occasionally amphigenous, 0.3–0.8 mm in diameter, on small reddish spots, scattered or in groups, pulverulent, cinnamon-brown; urediospores obovoid, pyriform or ellipsoid, frequently narrowed at the base, 18–23 × 20–32 μ; wall yellow, about 3 μ thick, finely and closely verrucose-echinulate, pores 4, equatorial. Teliospores in the uredia, ellipsoid, 18–25 × 25–35 μ, rounded at both ends, constricted at the septum; wall 3–4 μ thick, closely and finely verrucose, laminate, inner layer cinnamon- or light chestnut-brown, outer layer hyaline or yellowish; pores 2 in each cell, those in lower cell lateral, those in upper cell lateral, or occasionally 1 lateral and 1 apical; pedicel solid or thick-walled, hyaline, persistent, frequently slightly inflated in the lower one-fourth, 120–180 μ long.

HOSTS AND DISTRIBUTION: *Berberis atrocarpa* Schneid., Oregon; *Mahonia aquifolium* (Pursh.) Nutt., western United States, western Canada, Europe; *M. dictyota* (Jepson) Fedde, Calif.; *M. nervosa* (Pursh.) Nutt., Calif.; *M. pinnata* (Lag.) Fedde, Calif.; *M. piperiana* Abrams, Calif.; *M. pumila* (Greene) Fedde, Calif., Ore.; *M. repens* (Lindl.) Don., western United States.

TYPE SPECIMEN: On *Mahonia repens*, City Creek Canyon, Utah, July 3, 1880, Jones (Flora of Utah *1837*).

ILLUSTRATIONS: Magnus, Ber. Deutsch. Bot. Ges. **10**, Pl. 19, Figs.

1–7; Holway, N. Am. Ured., Pl. 4, Figs. 18a, 18b; Arthur, Manual of Rusts, Fig. 97; Savulescu, Monog. Ured. Rep. Pop. Rom. **2**: 532, Figs. 250, 251; this paper, FIG. 5 (from type).

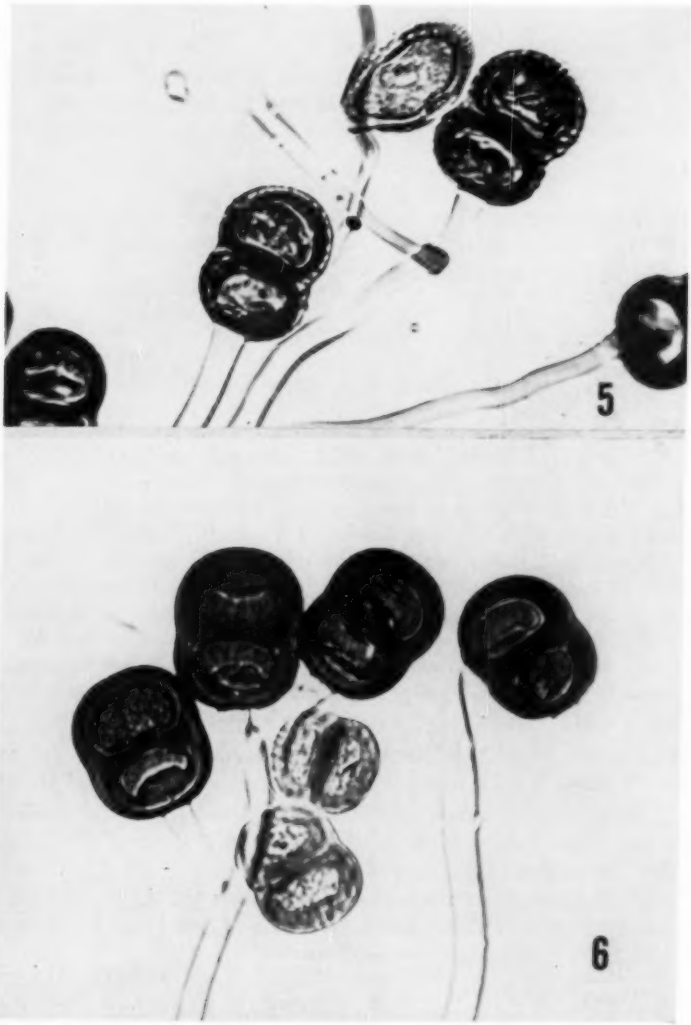

FIG. 5. Teliospores of *C. mirabilissima* (from type), × 800. 6. Teliospores of *C. wootoniana* (from type), × 800.

EXSICCATI: Barth. N. Am. Ured. *100, 1300, 1400, 1800, 1900, 2000, 2100, 2900;* Barth. Fungi Columb. *2770;* Syd. Ured. *879, 1777;* Griff. W. Am. Fungi *265;* Jacks. Fungi N. Am. *7087;* Standley Fungi N. Mex. *4085, 6767, 8181, 10937, 13585;* Solheim Myc. Sax. Exsicc. *80, 513, 514, 277.*

This species, like *C. texana,* shows some variation in the position of the pores in the upper cell of the teliospore. Occasionally one pore is apical or subapical while the other is lateral. When both pores are lateral they may be next to the septum or midway between the septum and the apex.

Successful cultures using aeciospores and teliospores on *Mahonia aquifolium* were reported by Hammarlund (**4**) in 1932.

The first name applied to this rust, *Uromyces sanguinea* Pk., is not valid, being based on uredia.

6. CUMMINSIELLA WOOTONIANA (Arth.) Arth., Bull. Torr. Bot. Club **60**: 475. 1933.

Uropyxis wootoniana Arth., Bull. Torr. Bot. Club **42**: 585. 1915.

Spermagonia and aecia unknown. Uredia hypophyllous, 0.3–1.0 mm in diameter, scattered, pulverulent, cinnamon-brown; urediospores fusiform, ovoid-fusiform or narrowly ellipsoid, 12–19 × 33–45 μ; wall 2–4 μ thick at sides, thickened to 6–10 μ at apex, yellow, closely verrucose-echinulate; pores 8–12, in 2 zones of 4–6 each. Telia hypophyllous, 0.3–1.5 mm in diameter, scattered, pulverulent, chestnut- or chocolate-brown; teliospores broadly ellipsoid, 15–30 × 18–33 μ, rounded at both ends, constricted at the septum; wall 3–5 μ thick, chestnut- or cinnamon-brown, longitudinally striate; pores 2 in each cell, usually next to the septum, occasionally midway; pedicel thick-walled or solid, hyaline, occasionally attached obliquely, slightly inflated in the lower one-fourth, 130–180 μ long.

HOSTS AND DISTRIBUTION: *Mahonia fremontii* (Torr.) Fedde, Arizona; *Mahonia haematocarpa* (Woot.) Fedde, Arizona, New Mexico.

TYPE SPECIMEN: On *Mahonia haematocarpa,* Filmore Canyon, Organ Mts., New Mexico, Nov. 9, 1908, Wooton.

ILLUSTRATIONS: FIG. 6 (from type).

The most distinctive feature of *C. wootoniana* is the sculpturing of the teliospore wall, which is striate with longitudinal ridges. The spermagonial and aecial stages are unknown.

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TAXONOMY OF THE PECAN SCAB FUNGUS

PAUL L. LENTZ [1]

(WITH 1 FIGURE)

Pecan scab is caused by a fungus that for almost thirty years has been called *Cladosporium effusum* (Wint.) Demaree (**1928**). Originally, Winter (**1885**) described this species as *Fusicladium effusum*, but Demaree transferred it to *Cladosporium* primarily because the conidia may be produced in chains. The type specimen was collected on *Carya alba*, which is a synonym for either *C. tomentosa* Nutt. or *C. ovata* (Mill.) K. Koch. Three years later, Ellis and Langlois, in an article by Ellis and Everhart (**1888**), reported the occurrence of a similar fungus on living leaves of *C. olivaeformis* Nutt. [= *C. illinoensis* (Wang.) K. Koch]. Although they recognized that this new fungus was scarcely distinct from *F. effusum*, Ellis and Langlois distinguished it on the basis of its epiphyllous, maculicolous growth and darker hyphae, and named it *F. caryigenum* Ell. & Langl. Orton (**1905**) reported that *F. caryigenum* is identical with *F. effusum* Wint.

Many years before *C. effusum* (Wint.) Demaree was used as the name for the pecan scab fungus, Berkeley and Curtis, in an article by Berkeley (**1875**), had described an altogether different fungus which they named *C. effusum* Berk. & Curt. The description was based on four specimens collected on hosts unrelated to *Carya*. These collections are now recognized as belonging in *Cercospora* (Chupp, **1953**, pp. 356, 357). Nevertheless, *C. effusum* (Wint.) Demaree is a later homonym of *C. effusum* Berk. & Curt. and thus cannot be used as a name for the pecan scab fungus (cf. Lanjouw et al., International Code of Botanical Nomenclature, **1956**, arts. 63, 64). This presents the necessity of selecting some other name for this fungus. The procedure necessarily involves re-examining the morphological relationships of the pecan scab organism. If it is found to be a *Fusicladium*, as originally presented, Winter's name may be accepted. If Demaree is correct in believing it to be a *Cladosporium*, consideration may be given to making a new combination based on *F. caryigenum*. However, this would be feasible only if *F. caryigenum* is found to be conspecific with *C. effusum* (Wint.) Demaree.

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One approach to the problem of naming the pecan scab fungus is to compare it with fungi that cause similar diseases of other plants. Some of these are the apple scab fungus, the peach scab fungus, and the pear scab fungus. In addition, *Cladosporium herbarum* Lk. ex Fr. must be considered because it is generally acknowledged to be the type species of *Cladosporium* (De Vries, **1952**, pp. 4, 7). Two papers by Hughes (**1953a**, **b**) present a useful basis for consideration of these fungi. In the first of these papers, Hughes (**1953a**) revived the name *Spilocaea* Fr. for fungi having conidial fructifications of the kind associated with apple scab, i.e., with annellate conidiophores. As the type of *Fusicladium* Bon. he accepted *F. virescens* Bon., which is synonymous with *F. pyrinum* (Lib.) Fckl. (or *F. pyrorum* as Hughes, **1953a**, suggested), the pear scab fungus. Viennot-Bourgin (**1949**, vol. 2, pp. 1487–1503) recognized the same basic conidiophore kinds as Hughes, but retained the name *Fusicladium* for the sort that Hughes assigned to *Spilocaea* and placed in *Megacladosporium* Vien.-Bourg. those species having the kind of conidiophore development characteristic of *Fusicladium* as interpreted by Hughes.

In his paper concerning the classification of the Hyphomycetes on the basis of the different kinds of conidiophores and conidium development, Hughes (**1953b**) defined eight sections. In Section I, the conidia ordinarily develop in acropetal succession as blown-out ends at the apices of simple or branched conidiophores which do not then increase in length. Hughes included *Cladosporium* in this section. In Section II, the conidia arise as blown-out ends at the apices of simple or branched conidiophores and at the ends of successively produced new conidiophore growing points that develop beyond, and relegate to one side, each previous conidial scar. *Fusicladium* belongs in this section. In Section III, the conidia arise solitarily as blown-out ends of the conidiophore apices, and additional conidia may be produced in succession through the attachment scars left by preceding conidia. This results in the annellate kind of conidiophore found in *Spilocaea*.

Demaree's (**1928**) decision to refer the pecan scab fungus to *Cladosporium* was based in part on a comparison of it with two other fungi which he called *Fusicladium dendriticum* (Wallr.) Fckl. and *Cladosporium carpophilum* Thüm. *F. dendriticum*, the apple scab fungus, was found to differ from the pecan scab fungus by failing to produce conidia in chains. (Hughes (**1953a**) considered *F. dendriticum* synonymous with *Spilocaea pomi* Fr.). Demaree found that the peach scab fungus, *C. carpophilum*, resembled the pecan scab fungus very closely in its development and morphology. Both produced conidia in chains.

In discussing the peach scab fungus, Hughes (**1953a**) wrote, "The very slightly denticulate conidiophores are similar to those of the type species of *Fusicladium* in that they produce conidia singly as the blown-out ends of successively produced growing points thereby being quite different from *Cladosporium* in which the conidiophore is of determinate length. The conidia . . . develop simple acropetal chains." Saccas (**1944**, figs. 53c, 54) showed that conidia of *F. pyrinum*, the pear scab fungus, may form in short chains of at least two or three conidia each. It is clear

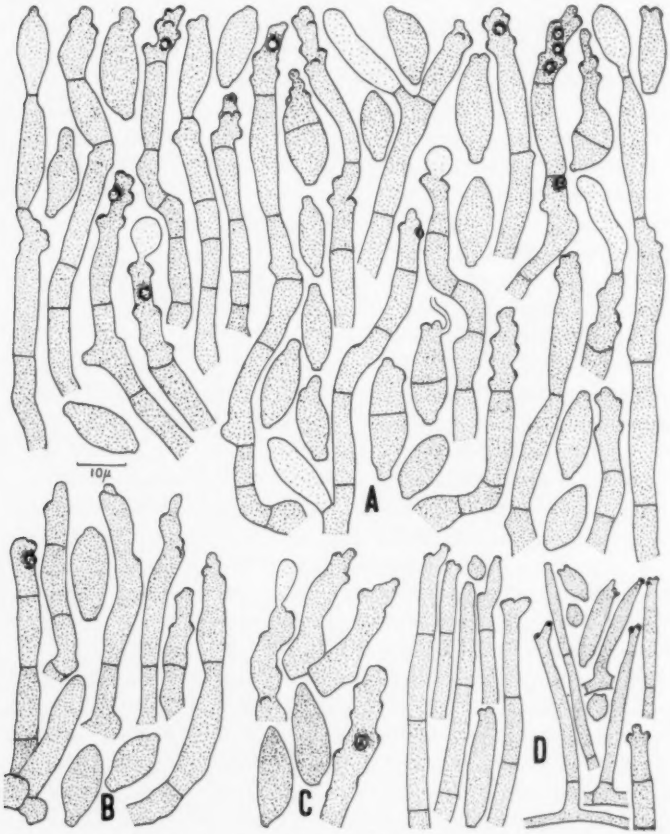

FIG. 1. Conidiophores and conidia. A. *Fusicladium effusum*, from 10 specimens. B. *F. caryigenum*, type. C. *F. pyrinum*, Sydow Myc. Germ. *1782*. D. *Cladosporium herbarum*, left: standard culture of Bisby; right: round-spored culture of Bisby. All × 750.

that production of conidia in chains is not acceptable as the sole basis for excluding the pecan scab fungus from *Fusicladium*. Examination of specimens in the National Fungus Collections reveals that the pecan scab fungus (FIG. 1, A) is congeneric with the pear scab fungus (FIG. 1, C) and the peach scab fungus, all belonging in Section II of Hughes (**1953b**).

Although *Cladosporium herbarum* in its more characteristic aspect seems to belong in Section I of Hughes, some features of its development bear a resemblance to those found in *Fusicladium*. In addition to several herbarium specimens of *C. herbarum*, dried examples of two cultures previously discussed by Bisby (**1945**) have afforded material for comparison (FIG. 1, D). During the formation of conidial chains, denticles are formed on the conidia of *F. effusum* and *C. herbarum*. In addition, Saccas (**1944**, figs. 53d, 54) illustrated similar denticles on conidia of *F. pyrinum*. Some conidia of *Fusicladium* (FIG. 1, A; Saccas, **1944**, figs. 53b, 54) may undergo prolongation of their denticle-producing axes in such a way that they then closely resemble the apices of typical conidiophores. Less extreme instances of apical proliferation were observed occasionally in specimens of *Cladosporium*. In some instances (FIG. 1, D) specimens of *C. herbarum* showed an apparent prolongation of the conidiophore apices, with production, at different levels, of more than one conidium attachment-point apparently in the manner of *Fusicladium*. A few conidiophores were almost as much developed in this respect as many of the *Fusicladium* conidiophores, but these were exceptional. The relationship between *Cladosporium* and *Fusicladium* seems close, although the aspect of the conidiophores is in general distinct and as Hughes (**1953b**) described. The morphological affinity of the pecan scab fungus with the peach scab fungus and the pear scab fungus is obviously more pronounced than any resemblance it may have to *C. herbarum*. Therefore it is proper to call the pecan scab fungus *Fusicladium effusum* Wint.

Any discussion of the recognition of *F. caryigenum* Ell. & Langl. as an acceptable basionym for the pecan scab fungus may now seem academic. Nevertheless, examination of the part of the type specimen (FIG. 1, B) in the National Fungus Collections shows that its morphology is similar to that of *F. effusum*. Thus *F. caryigenum* Ell. & Langl. is regarded as synonymous with *F. effusum* Wint. This is of particular importance only in the event that some may continue to regard the pecan scab fungus as belonging in *Cladosporium*, a circumstance that seems undesirable unless a change in taxonomic concepts alters recognition of relationships in *Cladosporium* and *Fusicladium*.

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A NEW SPECIES OF STREPTOTHECA

PHYLLIS S. BERGMAN AND LELAND SHANOR [1]

(WITH 7 FIGURES)

In the spring of 1953, the Mycological Research Laboratory of the University of Illinois received a culture of an interesting fungus, tentatively assigned as an unknown species to the genus *Streptotheca*, from Dr. C. W. Hesseltine of the Northern Utilization Research Branch, U. S. Department of Agriculture, Peoria, Illinois. It was isolated by Miss Dorothy Fennell at Peoria from a soil sample collected in 1952 by Dr. Harry Lunden, Royal Institute of Technology, Stockholm, Sweden, and designated "Pine Forest II-Stockholm." Miss Fennell reported that the "first evidence of its presence was the clouded area on the lid of the Petri dish where the ascospores had been deposited upon discharge." This unusual organism grows best at a temperature of approximately 5° C, a temperature which retards considerably or prevents the growth of many fungi. The ascocarp is extremely small and representative of the simple apothecial type.

Streptotheca psychrophila Bergman sp. nov.

Mycelium hyalinum. Ascomata minuta, glabra, hyalina, primo globosa-subglobosa, dein discoidea, 54–120 μ diam. Peridium hyalinum vel fuscum, 5.3 μ tenus densitate. Asci 32-spori, operculati, breviter stipitati, clavati, 31.5–54 × 12.8–24 μ. Ascosporae hyalinae, ellipsoideae vel subblobosae, glabrae, 3.8–8.3 × 3–5.3 μ. Paraphyses copiosae, hyalinae, septatae.

Mycelium mostly submerged, hyaline, cells uninucleate, colony zonate with older fruiting areas becoming tan-colored on drying, often with distinct clumps of aerial hyphae arising from the fruiting areas and bearing mature apothecia. Apothecia minute, not visible to the naked eye, gregarious or thickly crowded, hyaline, globose to subglobose becoming discoid on expansion, externally glabrous, 54–120 μ in diameter (average 87μ). Peridium composed of 1–2 layers of short-celled, thick-walled hyphae, often yellowish-brown, the whole wall not exceeding 5.3 μ in thickness (average 3.1 μ). Asci clavate, hyaline, operculate, slightly

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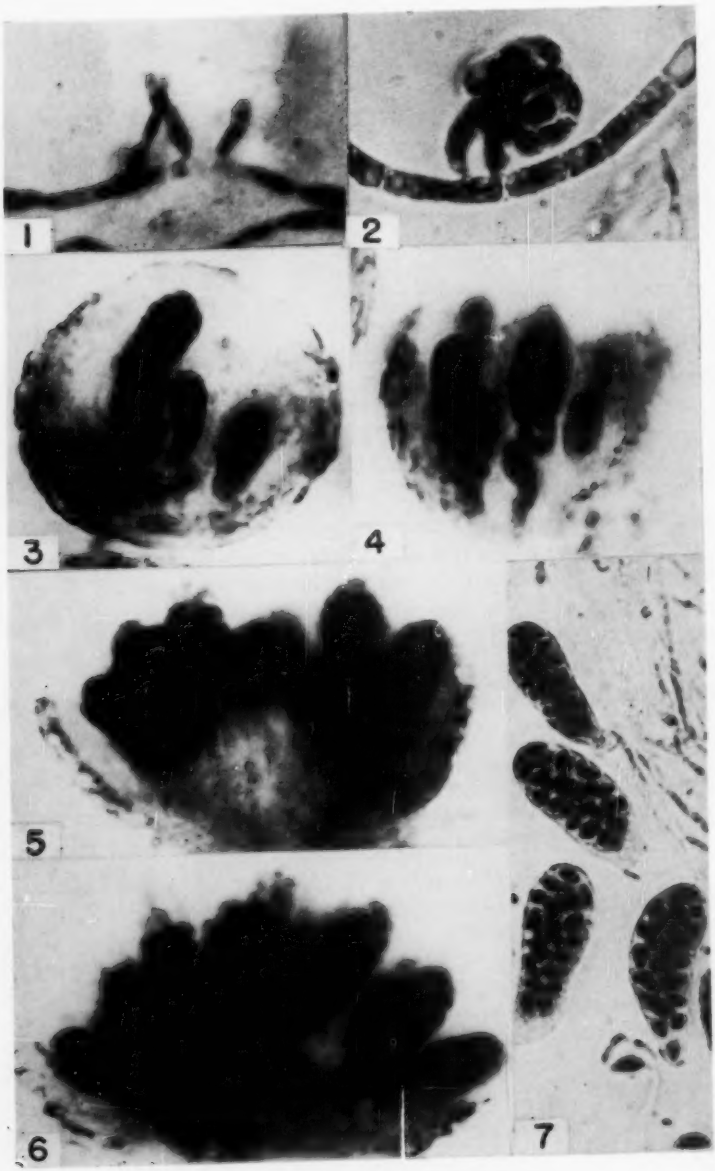

FIGS. 1–7.

constructed above near the apex with a ring or collar, 32-spored, short-stipitate, arising in parallel fashion from the base of the apothecium, 31.5–54 μ in length (average 38 μ) and 12.8–24 μ at their widest dimension (average 16 μ). Ascopores hyaline, ellipsoid to subglobose, 1-celled, smooth-walled, of two sizes, ranging from 3.8–8.3 μ in length (average 6.4 μ) and 3–5.3 μ in diameter (average 4.1 μ). Paraphyses numerous, slightly longer than the asci, septate, simple or slightly branched, hyaline, club-shaped, the tips being distinctly swollen and measuring 1.5–3 μ in diameter (average 2.1 μ).

TYPE LOCALITY: Stockholm, Sweden, from pine forest soil. Distribution: Known only from the type locality.

According to Seaver (**1942**), there are three recognized species in the genus *Streptotheca*: *S. crouani* (Renny) Seaver, *S. woolhopensis* (Renny) Seaver, *S. obscura* Seaver. This new one is probably closest to *S. crouani* which is also 32-spored. The other two species have 64-spored asci and form much larger ascocarps and asci. Having the same number of ascopores, however, appears to be one of the few characteristics which *S. crouani* and *S. psychrophila* have in common. According to Seaver, the apothecia of *S. crouani* may measure up to 0.5 mm 500 μ), while none of the fruiting bodies of this new species attain a diameter of more than 120 μ. The shape of the apothecium is the same for both species, globose at first and later becoming discoid. Seaver reports that there are a few external hair-like hyphae present on the fruiting body of *S. crouani*, whereas this new fungus has naked apothecia. The asci and ascospores of *S. crouani* are considerably larger than those of this new species. The asci of the former are 120 × 22 μ while those of the latter are 38 × 16 μ, and the ascopores of the former are 3 × 12 μ while those of the latter are more globose, measuring 4.1 × 6.4 μ. Both species have clavate asci and smooth-walled ascospores. Seaver describes the paraphyses as scant and very slender for *S. crouani*, while in *S. psychrophila* they are numerous, club-shaped, and either simple or slightly branched. In addition to these morphological differences between the two species, there apparently is an important difference in their optimum growth temperature. This new species grows best at about 5° C. While there is no record of the optimum temperature for the growth of *S. crouani*, it seems safe to assume that the optimum for

FIGS. 1–7. *Streptotheca psychrophila*. 1. Young gametangial initials, × 1240. 2. Early stage in formation of ascocarp indicated by mutual coiling of gametangial branches, × 1330. 3–6. Later successive stages in the development of the apothecium which is at first closed but becomes completely open at maturity, × 865. 7. Mature 32-spored asci, × 655.

this species is considerably higher, since an unusual temperature range surely would have been recorded. The fact that *S. crouani* has been isolated from the dung of various animals in New York and Europe (type locality) would seem to indicate also that the optimum temperature for *S. crouani* is well above that for the new species described here.

In 1874, Renny published a description of a small discomycete which he named *Ascobolus crouani* and placed in what he established as a new section which he designated as the section *Ascozonus*. Vuillemin (**1887**), apparently unaware of Renny's paper, established the genus *Streptotheca*, based on *S. boudieri* Vuill. (type) which he had studied. Saccardo (**1889**, **1892**) accepted Vuillemin's *S. boudieri* but assigned Renny's *Ascobolus crouani* to the genus *Ryparobius* as *R. crouani*. In 1907, Boudier raised Renny's section *Ascozonus* to generic rank, listing all the species included in Renny's study and suggesting that Vuillemin's *S. boudieri* was a synonym for his *Ascozonus crouani*. Because the descriptions of *S. boudieri* and *A. crouani* are essentially identical, Seaver believed them to be the same organism and has proposed *Streptotheca crouani* as the valid name on the basis of the international rule on priority of names, since the section *Ascozonus* was not raised to generic rank until after Vuillemin established the genus *Streptotheca*. Seaver has designated all other names mentioned above as synonyms of *S. crouani*.

Up to the present time, *S. crouani* and *S. psychrophila* are the only 32-spored species of *Streptotheca* which have been recognized. Since *Streptotheca psychrophila* differs so widely from all other recognized species of *Streptotheca*, it is proposed as a new species. Because of its unusual temperature requirements for a species of *Streptotheca*, the specific epithet *psychrophila* (ψυχρός-cold; φιλεῖν-to love) has been chosen.

SUMMARY

A previously undescribed species of simple discomycete is reported and given the name *Streptotheca psychrophila* Bergman. Apothecia are small, measuring up to 120 μ in diameter. Asci are 32-spored. The optimum temperature for growth and formation of arcocarps is approximately 5° C. The isolate on which the species is based was obtained from soil collected from a pine forest at Stockholm, Sweden.

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NOTES AND BRIEF ARTICLES

The Golden Anniversary of the Centraal Bureau voor Schimmelcultures—1907–1957

For three months this year I was a guest investigator at the Centraal Bureau voor Schimmelcultures (C.B.S.) in Baarn, Holland, during which time I gained a new and deeper appreciation of this unique mycological institution. The establishment of a "collection of living fungi for scientific research" was apparently first discussed in 1903 at a meeting of the Association Internationale des Botanistes in Leiden, stimulated in particular by Professor Dr. F. C. F. A. Went of the University of Utrecht. It was actually founded three years later at the Association's meeting in Paris. Went offered his own collection of fungi (partly of Indonesian origin) as the nucleus for this enterprise, and a list of nearly 80 available cultures under the title "Centralstelle für Pilzkulturen" (Fig. 1) was printed in the *Botanisches Centralblatt* (vol. 101) of that year. Cultures from the list could be purchased for a nominal sum, or they could be exchanged for other cultures not yet contained in the Collection. In 1907 the name of the infant collection was changed to the "Centraal Bureau voor Schimmelcultures" and, more importantly, it was turned over to Miss Johanna Westerdijk, newly appointed director of the Phytopathologisch Laboratorium "Willie Commelin Scholten" in Amsterdam. For 45 years Professor Westerdijk held the dual position of Director of the Centraal Bureau and of the Phytopathopathological Laboratory, with which the Collection has since been continuously associated. She retired from the latter post and from her professorships at the Universities of Utrecht and Amsterdam in 1952, being succeeded in these positions by Prof. Dr. L. C. P. Kerling; she still continues her directorship of the C.B.S.

The Centraal Bureau began to grow at once in size and in its contribution to science under the guidance of Professor Westerdijk. Even within the year 1907 a supplemental list of fungus cultures was offered to mycologists and plant pathologists. Many additional lists, each more extensive than the preceding, have followed these, and the present wealth of the Bureau's content is in part indicated by its current *List of Cultures*, published earlier this year (**1957**), which runs to 220 printed pages and includes 9693 cultures representing 6294 species in

Centralstelle für Pilzkulturen.

Die Kulturen folgender Pilze werden entweder im Tausch gegen andere Kulturen, welche die Centralstelle noch nicht besitzt, abgegeben, oder gegen Vorherbezahlung pro Kultur von fl. 1.50 (holl. Währung) für Mitglieder; und fl. 3 für Nichtmitglieder der Association. Die Anfragen sind zu richten an Herrn Prof. Dr. F. A. F. C. Went, Universität Utrecht (Holland).

Acrothecium lunatum Wäkker.
Alternaria tenuis Nees.
Aspergillus ~~auricomus~~ Guéguen.
„ *candidus* Link.
„ *clavatus* Desmazières.
„ *flavus* Link.
„ *~~fumigatus~~* Fresenius.
„ *glaucus* Link.
„ *niger* v. Tieghem.
„ *Oryzae* (Ahlberg) Cohn.
„ *ostianus* Wehmer.
„ *varians* Wehmer.
„ *Wentii* Wehmer.
Botryosporium pyramidale Cost.
Botrytis Bassiana Balsamo.
„ *cinerea* Pers.
„ *parasitica* Cavara.
Chaetomella horrida Oudem.
Chaetomium indicum Corda.
„ *Kunzeanum* Zopf.
Chlamydomucor Oryzae Went et Prinsen Geerligs.
Cladosporium butyri Jensen.
„ *herbarum* Link.
Clasterosporium Lini Oudem.
Diplocladium minus Bon.
Dipodascus albidus de Lagerheim.
Endomyces Magnusii Ludwig.
Epicoccum purpurascens Ehrenb.
Fusarium Solani (Mach.) Sacc.
„ *aquaeductum* (Rabenh.) Radlkof.
Gymnoascus candidus Eidam.
„ *Reessii* Baranetzky.
„ *setosus* Eidam.
„ spec. von Miss Dale.
Hypocrea Sacchari Went.
Monascus Barkeri Dangeard.
„ *purpureus* Went.
Monilia candida Bon.
„ *humicola* Oudem.
„ *javanica* Went et Prinsen Geerligs.
„ *sitophila* (Mont.) Sacc.
Monilia variabilis Lindner.
Mortierella isabellina Oudem.
Mucor alternans van Tieghem.
„ *circinelloides* van Tieghem.
„ *corymbifer* Cohn.
„ *javanicus* Wehmer.
„ (*Amylomyces* Calm.) *Rouxii* Wehmer
„ *spinosus* v. Tieghem.
Mycogone puccinioides (Preuss.) Sacc.
Myxococcus ruber Baur.
Penicillium brevicaule Sacc.
„ *olivaceum* Wehmer.
„ *purpurogenum* Fleroff.
„ *roseum* Link.
Phycomyces nitens Kunze.
Pyrenochaeta humicola Oudem.
Pyronema confluens Tul.
Rhizopus arrhizus Fischer.
„ *nigricans* Ehrenb.
„ *Oryzae* Went et Prinsen Geerligs.
Saccharomyces rosaceus Frankl.
„ *Vordermannii* Went et Prinsen Geerligs.
Sordaria humicola Oudem.
Sporodinia grandis Link.
Sporotrichum bombycinum (Corda) Rabenh.
„ *griseolum* Oudem.
„ *roseolum* Oudem et Beijer.
Stachybotrys alternans Bon.
„ *lobulata* Berkeley.
Stemphylium botryosum Wallr.
„ *macrosporoideum* (B. et Br.) Sacc.
Thamnidium elegans Link.
Thielaviopsis ethaceticus Went.
Trichocladium asperum Harz.
Verticillium glaucum Bon.
„ *rufum* (Schwabe) Rabenh
Wurzelpilz (Symbiont) von *Cattleya* Beijerinck.

FIG. 1. The complete list was printed as an unnumbered page in the *Botanisches Centralblatt*, vol. 101, 1906, along with announcements concerning the activities of the "Association Internationale des Botanistes." This was reproduced and distributed by Miss Westerdijk for the Centraal Bureau voor Schimmelcultures in 1907, the species *Aspergillus auricomus* and *A. fumigatus* being marked out as indicated.

genera from *Absidia* to *Zythia!* But Latin names and numbers of accessions alone do not reveal the true worth of a culture collection—the Centraal Bureau's greatness rests upon the more solid foundations of scholarship, imaginative research, and the painstaking care with which its cultures are maintained. From the beginning, Prof. Westerdijk set for herself the highest possible standards of laboratory practice, and

over the years she has received from her growing staff the same devotion to these ideals. It is not by accident or the lack of opportunities for its personnel elsewhere that the Collection has enjoyed an unusual continuity in its direction and in its professional staff.

The Centraal Bureau voor Schimmelcultures is managed by a Board of Trustees consisting of eminent Dutch biologists appointed in the main by the Phytopathological Laboratory "Willie Commelin Scholten" and by the Royal Netherlands Academy of Sciences. It is an interesting and significant fact that, during its entire history, this Board has had only three presidents: Prof. Went, from its beginning to 1946; Prof. Dr. A. J. Kluyver, from 1947 until his death last year; and Prof. Dr. V. J. Koningsberger, since 1956.

Prof. Westerdijk has, of course, guided the Collection throughout its first half-century, the story of its progress paralleling in its main outlines the flowering of her own distinguished career. She obtained the doctorate from the University of Zurich in 1906, and was appointed Professor of Plant Pathology at the University of Utrecht in 1917, being the first woman to occupy a university chair in the Netherlands. She was appointed to a professorship at the University of Amsterdam also in 1930. Resulting from her outstanding leadership of the Centraal Bureau and from her exceptional talents as a teacher of mycology and plant pathology, in which fields she has trained fifty-six doctorates, she has been the recipient of many high honors, both within her own country and abroad. Among these, she was elected to membership in the Royal Netherlands Academy of Sciences in 1951; she received the Otto Appel Medal at Heidelberg on the occasion of the "Pflanzenschutztagung" in 1953, and an honorary doctorate of the University of Uppsala in 1957. Perhaps the honor most cherished by her was of a more personal nature, this being a three-month, all-expense tour of South Africa, arranged by her many former students stationed in that Commonwealth.

Appropriate housing for the Centraal Bureau and its research activities has posed a recurrent problem. To obtain more room and facilities for experimental work and to accommodate the growing body of graduate students, she moved the Phytopathological Laboratory "Willie Commelin Scholten" and the Collection from Amsterdam to Baarn in 1920, occupying a large house near the Cantons Park used as Hortus Botanicus by the University of Utrecht. Subsequently, an old stable was remodeled into a student laboratory and lecture hall, the gift of a still anonymous benefactor. The main building has been remodeled and substantially enlarged; three much-needed rooms were added in 1928

with funds supplied by Mr. O. van Vloten, a friend of the Centraal Bureau. Since 1956 a large brick laboratory wing has been added to the W. C. Scholten-laboratory with the financial support of the University of Utrecht and of the University and the city of Amsterdam on behalf of the students in phytopathology. Thus in her semi-retirement,

FIG. 2. Professor Dr. Johanna Westerdijk.

and under the active supervision of Prof. Kerling, Dr. Westerdijk has realized her long-cherished dream of an adequate home for her beloved Centraal Bureau in the Phytopathological Laboratory.

The true strength of the Centraal Bureau rests in its staff of scientists and their technical assistants. These are for the most part career employees whose lives are centered upon the Collection. Additional to

FIG. 3. Professor Dr. L. C. P. Kerling.

Professor Westerdijk at Baarn, and Prof. T. Wikén, who succeeded Dr. Kluyver at Delft, the professional staff consists of outstanding mycologists and zymologists in their own right. Miss Westerdijk never fails to emphasize that without their tireless devotion it would have been quite impossible to maintain the Centraal Bureau through the difficult years of World War II and the years immediately following.

Revenues were sharply curtailed, agar and essential nutrients were most difficult to obtain, and during the bitter winter of 1944–45, when the laboratory was without electricity or any fuel, Petri dishes had to be sterilized at the gas works and culture media had to be prepared as best they could at the community kitchen maintained in the village by the occupying forces. With the exception of Miss Dra. M. A. A. Schipper, who was on vacation, the professional staff at Baarn is shown

FIG. 4. The professional staff—except Miss Dra. M. A. A. Schipper—of the Centraal Bureau voor Schimmelcultures in Baarn, July 1957. Left to right: Dr. G. A. de Vries, medical mycology; Miss Dr. G. E. Bunschoten, accession and distribution of cultures for almost 25 years; Miss A. L. van Beverwijk and Miss Dra. A. C. Stolk, culture verification and identification; Mrs. Dr. M. B. Schol-Schwarz, industrial mycology.

in the accompanying photograph (see legend FIG. 4) with a fractional portion of the Collection as a background. Not unimportant to the efficient operation of the C.B.S. is its prideful staff of assistants and technicians, of which the name of Jan Kiljan, who for 42 years has been in charge of the media kitchen at Baarn, may be cited as illustrative.

From the beginning, yeasts were included among the accessions of the Centraal Bureau. With the appointment of Dr. A. J. Kluyver as professor of Microbiology at the Technische Hogeschool in Delft, the management of C.B.S. in 1922 determined to physically divide the

Collection to encourage the development of a center for yeast investigations under his immediate supervision. The researches done in this laboratory by Prof. Kluyver and his students, and the monographs subsequently published by the staff amply demonstrated the wisdom of this decision and established the Delft School as the world's center of yeast investigation. In addition to Prof. Wikén, the professional staff of the Yeast Division at Delft consists of Miss Dra. W. Ch. Slooff, specialist in yeast identifications, and Mrs. Dra. N. J. W. Kreger-van Rij, coauthor of the authoritative monograph on yeast taxonomy: "Classification and Identification of the Yeasts." Whereas the Yeast Division has justly assumed a certain measure of autonomy it remains an integral part of the Centraal Bureau. Cultures of yeasts may be ordered from Delft directly or through the Collection's headquarters in Baarn.

The Centraal Bureau receives a part of its support from the sale of cultures, from the identification of specimens submitted for this purpose and from research work performed for industries. Such revenues, however, are quite inadequate for its operations, and additional income has and does come from other sources. A limited subsidy was provided by the Association Internationale des Botanistes until the dissolution of this sponsoring organization during World War I. Since that time, the Collection has been aided by the Royal Netherlands Academy of Sciences and the Agricultural Organization of the Central National Council for Applied Scientific Research in the Netherlands. During some years following World War II some assistance came from Unesco through the intercession of the International Union of Biological Sciences. Unesco has also given funds to buy essential scientific instruments. In recent years the C.B.S. has been subsidized by the Ministry of Education of the Netherlands Government. Limited sums have been contributed by industries, including one American pharmaceutical firm. The Collection has been strengthened by gifts from private individuals and by the important heritage of Mr. O. van Vloten. Prior to World War II an assistant was employed especially to examine fungi of Indonesian origin, his salary being paid by an annual grant from the Association of Experiment Stations for European Cultures in the former Dutch East Indies.

A new development has been the foundation of a special branch for the study of medical and veterinary mycology in 1952, the leader of which is Dr. G. A. de Vries. This branch is subsidized by the Health Organization of the National Central Council for Applied Scientific Research (T.N.O.).

The staff provides a service to mycology, plant pathology, and zymol-

ogy that is truly international in its scope and incalculable in its value. The Centraal Bureau richly deserves wide and generous support.

The expressed aim of the Centraal Bureau is "to collect all species of fungi that can be grown on sterilized media," and to achieve this end more than sixty different culture media are employed. In part this stems from the recognized requirements of certain groups and species of fungi; in part it reflects Prof. Westerdijk's credo that fungi, like men, appreciate and need a change in diet. The substrates used for any given group of cultures often represent a compromise between the recommendations of the contributing mycologists and the experience of the staff. Cultures are transferred periodically as necessary, generally at 4 to 6 month intervals but often much more frequently, in order to maintain them in a vigorous and, if possible, sporulating state. Two contrasting media are routinely used for each strain, e.g. *A* and *B;* at retransfer the culture from medium *A* is implanted on medium *B*, and *vice versa*. Several media may be used for a refractory strain which has lost or imperfectly exhibits some distinguishing characteristic. Likewise, changes in incubation temperatures may be employed to this end, as may also a reintroduction of the light and dark periods encountered by the fungus in its natural habitat. For the most part, the fungi are maintained as actively growing slant cultures, a procedure that is permitted by the cool and humid climate of Baarn without recourse to refrigeration. Immersion under sterile mineral oil finds application in certain special cases as does also soil preservation in others. Strong emphasis is now being given to lyophilization in the Yeast Division at Delft and a large proportion of their cultures have been so conserved. At Baarn this method is as yet little used for two reasons: first, a lack of sufficient personnel to undertake the processing of thousands of cultures, and second a reluctance on the part of Prof. Westerdijk to subject the fungi to freeze-drying. She is, as she says, a fungus gardner and she hates the thought of desiccating living plants—but quickly adds: "However, we shall do it!" That such a program will be undertaken soon is assured by the beautifully designed drying apparatus of large capacity that is now being assembled in one of the new laboratry rooms.

It was a most rewarding experience to spend a summer in the laboratories at Baarn, and I was deeply impressed by the amount of work that was being done and by the efficiency with which this was performed. The explanation is to be found in the inspired and contagious leadership which for a half-century has been provided by Prof. Westerdijk, and which has been captured by her very able and dedicated staff. In reminiscing one day, and with reference to her colleague Dr. Kerling,

Prof. Westerdijk remarked "We are just two little girls. We do the best we can." Viewed through the eyes of a visitor, the girls are doing a remarkable job!—KENNETH B. RAPER, University of Wisconsin, Madison, Wisconsin.

THE STIMULATORY EFFECT OF LIGHT UPON GROWTH AND CO_2 FIXATION IN BLASTOCLADIELLA. II. MECHANISM AT AN ORGANISMAL LEVEL OF INTEGRATION [1]

The aquatic fungus *Blastocladiella emersonii* [2] does not possess chlorophyll. And yet, submerged, liquid cultures of both the orange (BEM) and ordinary-colorless (OC) plants of *B. emersonii* proliferate more rapidly and produce greater yields of plant material in white light than in the dark.[3] Also, illuminated, growing cultures of orange plants grow more rapidly in bicarbonate media and fix more CO_2 *per unit weight of organism produced,* than those incubated in the dark.[3] That overall metabolic processes are altered simultaneously by illumination is indicated by a decreased rate of lactic acid production during the light accelerated growth.[3] Even in the absence of growth, the stimulatory effect of light upon CO_2 fixation is demonstrable *in vivo* with non-proliferating, ordinary-colorless plants. Indeed, it is demonstrable *in vitro* with cell-free extracts of *Blastocladiella*.[3] The results obtained so far have led to a tentative explanation of this light-stimulated growth in terms of a SKI (succinate-ketoglutarate-isocitrate) cycle.[3]

In order to pursue this phenomenon to a logical conclusion at a biochemical level of integration, it has become necessary to evaluate it and understand it at an organismal level of integration. This is being accomplished by growing populations of individual colorless plants for a single generation on solid media (PYG [4]) at 20° C. with and without illumination. When this is done, a striking phenomenon unfolds which is not easily demonstrable with the many, successive generations obtained in the liquid cultures used heretofore for biochemical work. At the time that dark-grown plants reach "maturity" (that is, when they begin to discharge swarmers), they are very much smaller in size than

[1] This work is being supported by research grants E-1568 from the National Institutes of Health, and G-2912 from the National Science Foundation.

[2] Cantino, E. C. and M. T. Hyatt. Ant. v. Leeuwenhoek. **19**: 25-70. 1953.

[3] Cantino, E. C. and E. A. Horenstein. Mycologia **48**: 777-799. 1956.

[4] Cantino, E. C. Amer. Nat. **86**: 399-404. 1952.

those subjected to 380 foot candles of white (fluorescent) light during growth (FIGS. 1, 2). The spore sacs of light-grown plants are from 5 to 10 times the volume of those of dark-grown plants, the exact value depending upon temperature, amount of light, and other environmental factors.

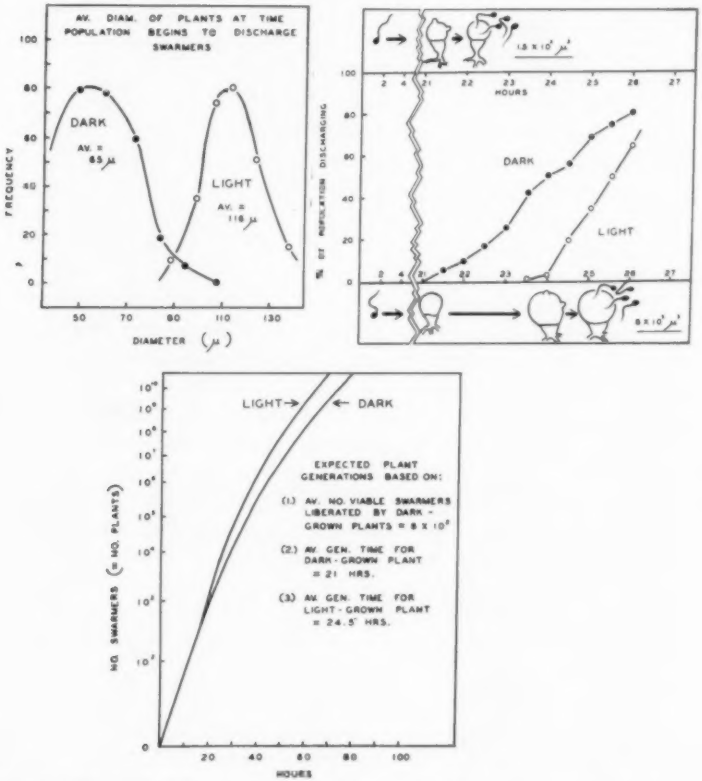

AV. DIAM. OF PLANTS AT TIME POPULATION BEGINS TO DISCHARGE SWARMERS
DARK
AV. = 85 μ
LIGHT
AV. = 116 μ
FREQUENCY
DIAMETER (μ)
% OF POPULATION DISCHARGING
HOURS
DARK
LIGHT
LIGHT→
← DARK
EXPECTED PLANT GENERATIONS BASED ON:
(1) AV. NO. VIABLE SWARMERS LIBERATED BY DARK-GROWN PLANTS = 8 X 10⁶
(2) AV. GEN. TIME FOR DARK-GROWN PLANT = 21 HRS.
(3) AV. GEN. TIME FOR LIGHT-GROWN PLANT = 24.5 HRS.
NO. SWARMERS (= NO. PLANTS)
HOURS

FIG. 1. Effect of light on *Blastocladiella*. Top left. The size distribution among populations of individual OC plants of *Blastocladiella* at the time that such plants have just begun to discharge swarmers. Plants were grown at 20° C on medium PYG in the presence and absence of 280 foot candles of white light. Top right. The time course of the discharge of swarmers by populations of individual OC plants. Details as for top left. Bottom. An estimate based upon the data delineated in top, right and left, of the increase in yield (e.g., total plants) that would be expected theoretically in submerged, liquid cultures grown in the dark and under 100 to 300 foot candles of illumination.

By extrapolating with these experimental data, we have estimated (FIG. 3) that theoretically, for submerged, liquid cultures this should lead to a five- to ten-fold increase in total plants, or total "growth," over a period of five or six generations if other limiting factors (accumulation of metabolic products, depletion of nutrients, etc.) do not enter significantly into the picture. Indeed, the results correspond well with the actual increases in yield of liquid cultures induced by illumination, as determined in earlier work,[3] which have been of this same order of magnitude.

The quantity of light necessary to induce the effect is not high. Degree of stimulation rises linearly with increasing intensity to about 100 foot candles, which yields maximum results; further increase in intensity up to 300 foot candles neither stimulate nor inhibit. The effective spectrum lies in the 400 to 500 mμ range. So far, the light receptor has not been identified, but it appears not to be carotene, flavin, or flavoprotein.

Colorless plants of *Blastocladiella emersonii* contain neither chlorophyll nor detectable quantities of alpha, beta, or gamma carotene. And yet, light induces much more rapid growth and it brings about greater rates of CO_2 fixation, per unit weight of organism, with both proliferating and non-proliferating plants. Thus, it would seem as if *B. emersonii* is perched nicely in the midst of Woods' and Lascelles' "no man's land between the autotrophic and heterotrophic ways of life."[5] Furthermore, it adds to the smog in which we flounder with decreasing visibility as we try to stereotype the "heterotrophic" fungi and try to distinguish them from their photosynthetic relatives in the plant kingdom. We cannot help but wonder, too, how many of the relatives of *B. emersonii* in the Blastocladiaceae—and for that matter, how many of its more distantly allied aquatic kin—will contribute to this haze when the search is made.

The light-stimulated growth of *Blastocladiella* seems to result directly from a pronounced increase in size over a short four- or five-hour period toward the end of the generation time of a plant. We expect that continued studies will help us to relate this phenomenon, at an organismal level of integration, to the associated increase in CO_2 fixation and related changes in metabolic machinery,[3] at a biochemical level of integration.—EDWARD C. CANTINO and E. A. HORENSTEIN, Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan.

[5] Woods, D. D. and J. Lascelles. Autotrophic Microorganisms, 4th Sympos. Soc. Gen. Microbiol. (London) **1954**: 1-27. 1954.

PROTOPLASMIC CONNECTIONS BETWEEN CELLS IN SCLEROTIA OF CERTAIN ASPERGILLUS AND PENICILLIUM SPECIES

Morphological studies of mature sclerotia in *Aspergillus* and *Penicillium* have revealed the presence of numerous protoplasmic connectives between thick-walled pseudoparenchymatous sclerotial cells. Freez-

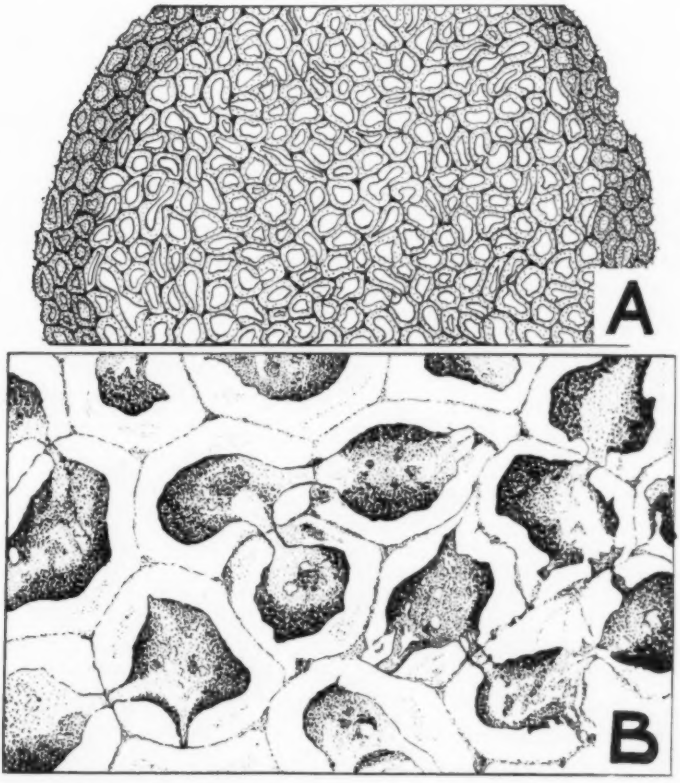


FIG. 1. A. Freezing microtome section of a *Penicillium Thomii* sclerotium. B. Above section greatly enlarged showing prominent protoplasmic connections.

ing microtome and paraffin-embedded sections of sclerotia in 11 species were prepared. Two species, *Penicillium nova-zeelandiae* van Beyma and *P. purpurogenum* Stoll var. *rubri sclerotium* Thom, possessed discrete unconnected protoplasts. The following organisms displayed prominent cell connections in all or a part of the sclerotial elements:

Aspergillus candidus Link
A. flavus Link
A. niger van Tieghem
A. sclerotiorum Huber
A. alliaceus Thom & Church
Penicillium Thomii Zaleski
P. sclerotiorum van Beyma
P. Raistrickii Smith
P. gladioli Machacek

Under high magnification the protoplasmic connections or cytoplasmic extensions appear stretched and joined to neighboring cell cytoplasms at the cell faces (FIGS. 1A, B). As many as six such connections have been observed in one cell. As seen in FIG. 1B the cytoplasmic extensions are quite broad and apparently continuous as they pass through the cell wall. Methods for demonstrating plasmodesmata did not reveal discontinuity of the wide connectives.

Brefeld, in 1874, described and illustrated similar connections in the sclerotial-like perithecia of *Penicillium glaucum*.[1] These were described as cell wall pits closed by thin membrane plates. Membrane plates were not observed in the present investigation. A further study utilizing electron microscopy is planned.—C. L. PORTER AND JOHN H. COATS, Department of Biological Sciences, Purdue University, Lafayette, Indiana.

A RUST ON VIRGINIA PINE AND BUCKLEYA

In 1952, Hepting and Cummins [1] described a new species of *Peridermium* (*P. appalachianum*) on *Pinus virginiana* Mill. occurring in several southern Appalachian states. Up to the time of the above report, no evidence had been obtained as to a possible alternate host. During the late summer in 1953, Dr. A. B. Massey of Virginia Polytechnic Institute sent the writer some leaves of *Buckleya distichophylla* (Nutt.) Torr. that bore telia of a *Cronartium*.

On the chance that the *Cronartium* on *Buckleya* might be the alternate stage of the Virginia pine *Peridermium*, Dr. Massey was solicited for more material to use in inoculations, and a search was made for *Buckleya* near rust-infected Virginia pine at several locations. *Buckleya*

[1] Brefeld, O. Die Entwicklungsgeschichte von *Penicillium* Bot. Unters. über Schimmelpilze **2**: 1–98. 1874.

[1] Hepting, George H., and George B. Cummins. A new species of Peridermium on Virginia pine. Phytopathology **42**: 115–116. 1952.

bushes, the leaves of which were heavily infected with a *Cronartium*, were found under and around Virginia pines bearing cankers of *P. appalachianum* along the Nolichucky River near Erwin, Tennessee, in 1955, and near Asheville, North Carolina, in 1956.

INOCULATIONS ON PINE

During the summer and fall of 1953, attempts were made to inoculate potted wildling Virginia pines with aeciospores in one series, and with sporidia from *Buckleya* in two other series. In all cases the inoculated plants were placed in a frame enclosed with wet muslin at approximately 65° F. In the first series, fresh aeciospores were dusted over the previously mist-sprayed trees and the plants kept inside the wet muslin "iceless refrigerator" for 72 hours. In the second series, the procedure was the same, but several telium-bearing *Buckleya* leaves from Virginia were clipped in the top of each tree. In the third series, similar infected *Buckleya* leaves from Erwin, Tennessee, were used. Altogether 96 trees were inoculated and 6 checks were used.

In addition, telium-bearing *Buckleya* leaves were suspended over Virginia pine shoots in the field, inside celluloid cones wrapped in wet batting. In still another field group, telial columns were inserted in bark slits in current succulent shoots and the shoots put in cones for 72 hours. The field inoculations were made on September 16, 1953. As of the summer of 1957, four growing seasons after inoculation, there is no evidence of cankers on any of the inoculated trees.

INOCULATIONS ON BUCKLEYA

During the fall of 1954, a number of small *Buckleya* plants near Erwin, Tennessee, were identified and marked. In the early spring of 1955, long prior to leafing out, these plants were brought to Asheville, North Carolina. In mid-April, shortly after they leafed out, 4 plants were sprayed with water, dusted with fresh aeciospores from 2 Virginia pine cankers, and placed in celluloid cones for 72 hours in the shade. Two sprayed checks were used.

All of the plants except 1 inoculated and 1 check plant were almost killed by a spell of extreme cold. On May 5, the surviving inoculated plant was reinoculated and again put in the cone. The check plant was sprayed but not inoculated, and put in a cone for 72 hours. Eleven days later uredinial sori first appeared on the inoculated plant. On May 26, 23 leaflets bore uredosori, with a total of 74 sori on the plant. The check plant was unaffected. Thus *Buckleya distichophylla* is regarded as the alternate host of *Peridermium appalachianum*.

In the spring of 1956, John S. Boyce, Jr., dusted aeciospores from fresh Virginia pine cankers on 8 small *Buckleya* plants atomized with water. Uredia (14 sori) appeared in 10 days on 2 of the inoculated plants, and on neither of the atomized checks. The plants were covered with celluloid cones or wet muslin for 48 hours after inoculation. By the 22nd day, 41 uredia had appeared.

DESCRIPTION OF THE STAGES ON BUCKLEYA

The uredia are hypophyllous and caulicolous, scattered or aggregate, round, small, dehiscent by a central pore; uredospores globoid to obovate, average 14 μ (mostly 13 to 15 μ) wide, by 21 μ (mostly 18 to 23 μ) long; wall nearly colorless, 1.2 to 1.7 μ thick, finely echinulate.

The telial columns are hypophyllous and caulicolous, cylindric, mostly 0.5 to 2.0 mm long; teliospores oblong or cylindric, average 10.2 μ (mostly 8 to 12 μ) wide, by 32.1 μ (mostly 30 to 34 μ) long; wall nearly colorless, uniformly 0.6 to 1.0 μ thick, smooth.

Cronartium appalachianum sp. nov.

Peridermium appalachianum Hepting & Cummins, Phytopathology **42**: 115. 1952.

Uredia hypophylla et caulicola, dispersa vel aggregata, rotunda, parva, poro centrali dehiscentia; urediosporae globosae usque obovatae, 13–15 × 18–23 μ, membrana fere hyalina, 1.2–1.7 μ crassa, subtiliter echinulata; columellae teliosporarum hypophyllae et caulicolae, cylindricae, 0.5–2 mm longae; teliosporae oblongae vel cylindricae, 8–12 × 30–34 μ, membrane fere hyalina, uniformiter 0.6–1 μ crassa, glabra.

On *Buckleya distichophylla* (Nutt.) Torr. in Virginia, North Carolina, and Tennessee, U. S. A.

On leaves of *B. distichophylla* New River, near Blacksburg, Virginia, September 1953, *Massey F.P. 99776;* Nolichucky River, Erwin, Tennessee, *Matthews F.P. 99777* (type); and Asheville, North Caroline. Type specimen deposited in U. S. Department of Agriculture collection at Beltsville, Maryland. Other collections deposited in the Forest Service pathology herbarium at Asheville, North Carolina, and the Arthur Herbarium, Purdue University.

The uredospores are smaller than those of any other North American *Cronartium*. The aeciospores are also unique in being narrower than those of the other *Cronartiums* described by Arthur,[2] who lists *Buckleya*

[2] Arthur, J. C. Manual of the rusts in United States and Canada. 438 pp. Lafayette, Ind. 1934.

distichophylla as a host of *Cronartium Comandrae*. A complete description of the *Peridermium* stage on Virginia pine has already been published.[1]

Great difficulty has been experienced in germinating fresh, mature aeciospores, washed or unwashed, even using a wide range of temperatures, and in tap water, boiled water (with and without fragments of *Buckleya* leaves), distilled water, 0.1 and 0.3% orange juice in water, and 0.1 and 0.5% sucrose in water. Only an occasional germinating spore has been observed.—GEORGE H. HEPTING, Southeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Asheville, North Carolina.

A NEW EXIDIA

Exidia hispidula sp. nov.

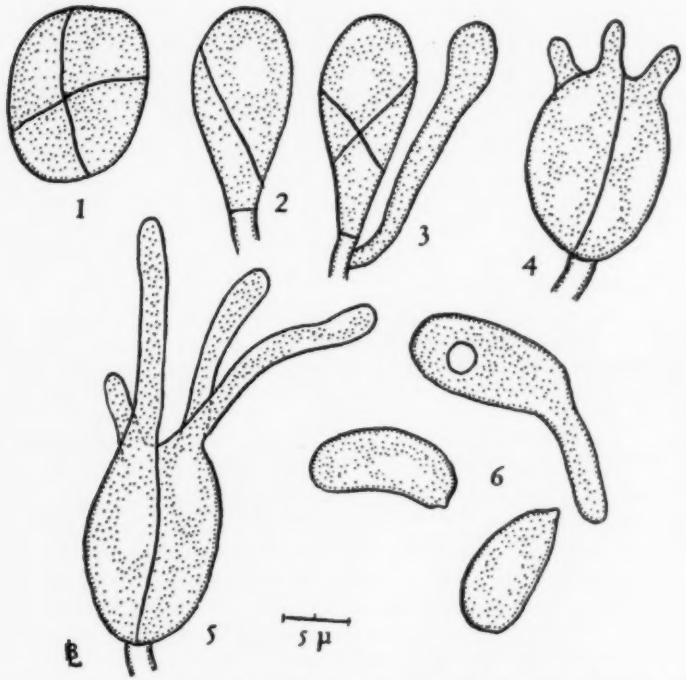
Fructificatio humida cartilagineo-gelatinosa, alba vel sordide hyalina, multipapillosa, superficie gyrosa, non coalescens; sicca ceraceo-cornea, primum griseo-alba deinde olivacea; margine hyalino-fimbriato, fimbriis ad 125 μ longit.; hyphae enodosae, 2–3 μ diam.; probasidia subglobosa vel clavata, cruciatim septata, (7–)8–10 × (10–)12–16 μ; epibasidia subcylindracea, 2–3 μ diam.; basidiosporae aseptatae, ovoidea vel allantoidae, hyalinae, 9–13(–14.5) × 5–7 μ; per repetitionem germinantes vel promycelium promittentes. Ad truncos deciduos arborum frondosarum crescit.

Fructification tough-gelatinous when wet, greyish-white, gyrose, densely papillate, occurring in patches up to 8 × 5 mm and 3 mm thick; drying to ashy-grey (at first, becoming olivaceous after repeated soakings) convoluted to more or less flattened pustules having a tough, waxy-cartilaginous consistency; attached by a root-like base which penetrates the substrate; margin hairy, hairs hyaline and most conspicuous when dry, grouped in small pointed fascicles up to 125 μ long; papillae sterile, cylindrical, up to 75 × 35 μ; hymenium unilateral, inferior, with basidia in a zone up to 75 μ wide, covered by a sterile outer zone 10 to 20 μ wide; hyphae 2–3 μ in diameter, without clamp connections; probasidia subspherical to broadly clavate or pyriform, becoming cruciate-septate, (7–)8–10 × (10–)12–16 μ; epibasidia up to 60 μ long, subcylindrical, 2–3 μ in diameter; dikaryoparaphyses clavate, arising directly below the basidia; basidiospores ovoid to allantoid, hyaline, 9–13(–14.5) × 5–7 μ; germinating by germ tube or by repetition.

Collected 5 miles south of Louisiana State University, Baton Rouge, Louisiana, on the under surface of a rotting, corticate log, April 19, 1957, B. Lowy, J. L. Dean, N. Zummo. 8253, TYPE. The type is deposited in the mycological herbarium of Louisiana State University with

portions in the herbaria of the State University of Iowa and the New York Botanical Garden. FIGS. 1–8.

Through the courtesy of Dr. D. P. Rogers, the following collections of *Exidia cartilaginea* were examined: *Exidia cartilaginea* Lundell & Neuhoff. 6–X–1935. leg. Seth Lundell, Bondkryka parish, Värdsätra

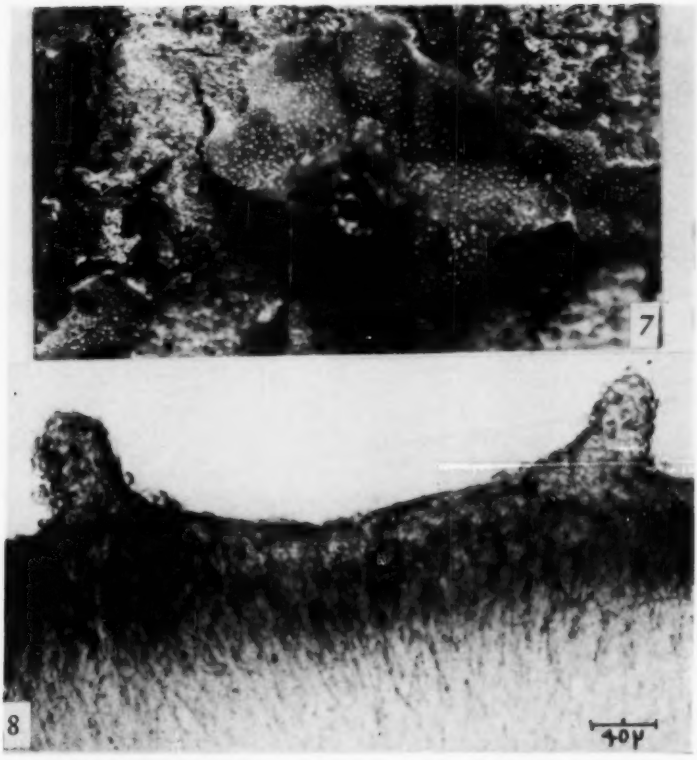


FIGS. 1–6. *Exidia hispidula*. 1. Cruciate-septate probasidium. 2. Clavate probasidium with single oblique septum. 3. Clavate probasidium with 2 oblique septa and dikaryoparaphysis. 4–5. Stages in epibasidial development. 6. Three basidiospores, one germinating by germ tube.

(near Upsala); *Exidia cartilaginea* Lundell & Neuhoff. 27–VII–1950. G. W. Martin, Sweden: Handöl (Jämtland); *Exidia cartilaginea* Lundell & Neuhoff. 2–VII–1931. Bear Island, Lake Timagami, Ontario, Canada. Coll. R. F. Cain, Det. Neuhoff.

In Neuhoff's [1] monograph on *Exidia*, 13 species are included and the

[1] Neuhoff, W. Die Gallertpilze. Die Pilze Mileteuropas 2: 7–49. 1935–38.



FIGS. 7–8. *Exidia hispidula*. 7. Dried, apx. × 5. 8. Freehand transverse section through inferior surface of basidiocarp, showing 2 papillae, layer of basidia in hymenium and hyphae of subhymenium.

descriptions of two of them, *E. cartilaginea* and *E. villosa*, suggest a resemblance to the new species. However, examination of authentic material of *E. cartilaginea* leaves no doubt that it is quite distinct from *E. hispidula* in several important respects, which may be summarized as follows:

	Exidia cartilaginea	*Exidia hispidula*
Hairs	up to 2 mm long	not more than 0.2 mm long
Growth habit	broadly effused, becoming confluent	not becoming confluent
Basidiospores	11–13 × 4–4.5μ	9–14 × 5–7μ
Clamps	present	absent
Papillae	few	many

I have not seen *Exidia villosa* Neuhoff, but have studied Neuhoff's descriptions and illustrations and am conviced that *E. hispidula* is distinct from this species as well.—BERNARD LOWY, Department of Botany, Bacteriology and Plant Pathology, Louisiana State University, Baton Rouge, Louisiana.

KORDYANELLA

The monotypic genus *Kordyanella* Höhn. is characterized, according to its author, by the possession of slender cylindric, mostly disterigmate basidia forming a hymenium over the surface of a minute hemispherical or pulvinate basidiocarp. The fungus seems to have been reported but the once. The original description might suggest affinity of Höhnel's fungus to the Dacrymycetaceae. Some of the pecularities, however, which Höhnel attributed to the basidium led Neuhoff (Bot. Arch. **8**: 282–286, 288. 1924) to associate *Kordyanella* with *Kordyana*, *Brachybasidium*, and the Tilletiaceae; in more general terms, Neuhoff saw in Höhnel's genus the common ancestor of nearly all Heterobasidiomycetes.

Höhnel's description and Neuhoff's hypothesis both make the fungus an object of considerable interest. Accordingly I examined the type specimen of *Kordyanella austriaca* Höhn., Ann. Myc. **2**: 274. 1904, and Höhnel's own microscopic preparations of it, which are well preserved in the Farlow Herbarium. The sporophores of *Kordyanella* are endoconidiophores: the two sterigmata are the two lateral walls of the cylindric terminal segment of the conidiophore seen in optical section;[1] presumably the occasional third and fourth sterigma reported for the fungus are the result of focusing up or down on the upper or lower walls of the same cylindric cell. The fructification is not a basidiocarp, but a sporodochium.

The correct assignment of *K. austriaca* I do not know; it is at any rate of no importance to the study of the Basidiomycetes. Höhnel's fungus can be traced in Clements & Shear to the genus *Hymenella* Fr., Syst. Myc. **2**: 233. 1822; it also closely resembles the genus *Tremellidium* Petr., Ann. Myc. **25**: 387. 1927.—DONALD P. ROGERS, Department of Botany, University of Illinois, Urbana.

[1] It is as though one were to remove the endoconidia from the drawing of *Sporoschisma mirabile* in Sacc., Fung. Ital. fig. 928 (or Clements & Shear, Genera of Fungi. pl. 56, fig. 13a), and interpret the empty conidiophore as a disterigmate basidium related to the basidium of *Dacrymyces*.

ON THE TYPE OF AMYLIROSA AURANTIORUM SPEG.

On several occasions different workers have requested the type material of this micromycete, but their wishes were not satisfied due to the fact that it was impossible to locate it in Spegazzini's Herbarium. We are pleased to report that a fortuitous circumstance allowed us to find it. While examining materials of Mucorales, we came across an envelope with the inscription "*Amylomyces heterospermum* Speg. nov. sp. *Citrus aurantium,* Asunción, X–1919," which had been accessioned as LPS No. 287.

Our attention was called to this by the fact that the drawings on the cover of the envelope, made by Spegazzini himself with his customary neatness and detail, obviously belonged to an ascomycete. This observation and the data on host and area led us to compare the original drawings with those published as illustration of *Amylirosa aurantiorum* Speg. nov. gen. et sp. (An. Soc. Cient. Arg. **90**: 178–179. 1920), thus verifying that they pertained, without any doubt, to the type material of the latter.—JUAN C. LINDQUIST AND JORGE E. WRIGHT, Instituto C. Spegazzini, Universidad Nacional de La Plata, Calle 53 No. 477, La Plata, Argentina.

IX INTERNATIONAL BOTANICAL CONGRESS

The Ninth International Botanical Congress will be held in Montreal, Canada, from August 19 to 29, 1959, at McGill University and the University of Montreal. The program will include papers and symposia related to all branches of pure and applied botany. A first circular giving information on program, accommodation, excursions, and other detail will be available early in 1958. This circular and subsequent circulars including application forms will be sent only to those who write to the Secretary-General asking to be placed on the Congress mailing list. Address Dr. C. Frankton, Secretary-General, IX International Botanical Congress, Science Service Building, Ottawa, Ontario, Canada.

CHANGE OF EDITORS

As of January 1, 1958, the Editor-in-Chief of MYCOLOGIA will be Dr. Donald P. Rogers. Manuscripts and correspondence concerning editorial business should be addressed to him at the Department of Botany, University of Illinois, Urbana, Illinois.

As of February 1, 1958, Dr. Clark T. Rogerson will become Managing Editor of MYCOLOGIA as well as Curator in charge of the cryptogamic collections at the New York Botanical Garden. All correspondence intended for the Managing Editor should be addressed to him at the Garden.

REVIEWS

MICROBIAL ECOLOGY, edited by R. E. O. Williams and C. C. Spicer. The Seventh Symposium of The Society for General Microbiology. viii + 388 pp. Cambridge University Press. 1957. Price, 32 shillings, 6 pence (about $4.50).

This book, the seventh symposium of the Society for General Microbiology, perhaps indicates a growing interest in microbial ecology. However, if we accept the definition of ecology advanced by Shepherd in the opening article of this book, "Ecology is a study of the interactions of organisms and environments," then ecology becomes synonymous with the whole of biology. Perhaps most mycologists will prefer to restrict ecology to the study of the interaction of organisms in "natural" environments. In this context, the articles by Hewitt, Stanier and Cohen-Bazire, and Johnson will be relegated to the domain of physiology. Other articles are rather medically oriented and since they present few new ecological concepts, will probably not interest mycologists.

This still leaves a number of articles of considerable interest. P. W. Brian reviews the ecological significance of antibiotic production and gives an excellent, objective account of this difficult question. There is little doubt that certain antibiotics can be produced under natural conditions in the soil. Whether this production is of ecological significance leading to advantages for the antibiotic producer remains an open question due to the serious methodological difficulties. Brian is willing to believe this production is of ecological significance on the basis of indirect evidence. C. L. Duddington gives a very lucid account of the predacious fungi and their place in microbial ecology. He points up the need for much more quantitative work on this interesting group. The problem of the survival of fungi under natural conditions is discussed by Lilian E. Hawker. She outlines the various devices used by fungi to provide for survival of the individual and survival of the species. Since most of the research in this area has been with pure cultures, the obvious need for study under field conditions is indicated.

An account of a new technique for direct study of fungal activity in soil is presented by H. T. Tribe. This consists of burying sterile cellophane strips attached to cover slips in soil, then digging them up from time to time to observe by microscopical means the succession of organisms that gradually destroy the cellophane. As would be expected,

fungi come up first and are later followed by bacteria when the fungi die. The predominant fungi, *Botryotrichum, Chaetomium, Humicola, Stachybotrys, Stysanus* and chytrids, are not the fungi usually isolated from soils by common plating methods. This direct technique may show considerable promise for the study of fungal activity in the soil.

F. C. Bawden's article on the role of plant hosts in microbial ecology presents some concepts that are familiar to most plant pathologists. Most of his examples are derived from the fungi. A discussion by M. Ingram of halophilic bacteria and osmophilic yeasts rounds out the mycologically oriented articles. Much of this work on osmophiles is strictly physiological in nature. The yeasts are less well understood than the bacteria.

The rest of the articles are on bacteria, viruses or protozoa and will be of less interest to mycologists, although each illustrates at least one principle with applications to the fungi. The writing in general is excellent, and platitudes and vague generalizations are skillfully avoided. It is to be hoped that this volume will stimulate further research in microbial ecology.—THOMAS D. BROCK.

THE PHYSIOLOGY OF REPRODUCTION IN FUNGI, by Lilian E. Hawker. 128 pp., 5 figs. Cambridge University Press, New York. 1957. Price, $3.00.

Mycologists are well aware of the wide diversity amongst the fungi, ranging as they do from the smallest chytrid to the largest puffball, and, in life cycle, from the complicated water molds to the simple Deuteromycetes. This diversity is well emphasized by the present book, attempting as it does to cover the physiology of reproduction in *all* the fungi.

Perhaps it is this overwhelming diversity of reproduction types that has prevented us from knowing much about the physiology of reproduction of any one type. Because when one finishes reading this book, one realizes that practically nothing is known about reproduction at the cellular level. There have been countless observations on sporulation and fruiting, but these observations only indicate that these processes are probably not the same in different fungi. One wishes that mycologists would make a concentrated study on one favorable genus, so that we could have the depth of knowledge for which our present breadth does not substitute.

At any rate, Hawker has collected the bulk of the literature in this

field and has done an admirable job of unifying something which has no essential unity. After a brief discussion of the anatomy of reproduction, she proceeds to discuss the physiology of vegetative reproduction, sporulation, fruiting and sex, and concludes with some observations on reproduction in natural habitats. Since Miss Hawker herself has done much work to advance our knowledge of these subjects, she can and does write with authority.

Over 300 references are cited in a book of 128 pages. Since the price is only $3.00, it is a book that most mycologists will probably wish to have on their shelves, if only to use as an occasional reference book.—THOMAS D. BROCK.

DANISH PYRENOMYCETES, by Anders Munk. Dansk Botanisk Arkiv. Bind 17, Nr. 1. 491 pp. Ejnar Munksgaard, Copenhagen, 1957. Price, 100 Danish Kr. (about $14.50).

This is a manual covering all of the pyrenomycetous fungi of both the Ascoloculares and the Ascohymeniales. As such it will serve as a very practical handbook for determination of this extensive group of fungi. The approach is conservative, although some of the author's viewpoints as to taxonomic arrangement are naturally included. The treatment is a practical and usable one, which is important for the non-specialist. In general the family treatment is that of the more recent ones of von Arx, Mueller, and Moreau.

Brief diagnoses are given for each genus and keys to all of the larger ones. Most of the genera are illustrated. All species are fully described, but the reader is usually referred to other works for synonymy. A useful species index and bibliography are appended.

There is an unfortunate use throughout the manual of the term form genus for the ascus stage of these fungi, a term generally used for the asexual or conidial stage.—L. E. WEHMEYER.

ÉTUDES TAXONOMIQUES SUR LES PLÉOSPORACÉES, by Lennart Holm. 188 pp. Symbolae Botanicae Upsaliensis XIV : 3. A.-B. Lundequistska Bokhandeln, Uppsala. 1957. Price, Swedish Kr. 20 (about $2.00).

This doctoral thesis of Lennart Holm is the result of some years of intensive collecting and study of this group of fungi in Scandinavia. It deals with the phragmospore genera of the family Pleosporaceae sensu Luttrell. The genera recognized and the number of species of each are

as follows: *Leptosphaeria* Ces. & de Not. (35), *Melanomma* Nit. & Fck. (12), *Ophiobolus* Riess (2), *Nodulosphaeria* Rab. (18), *Leptospora* Rab. (1), *Phaeosphaeria* Miyake (17), *Entodesmium* Riess (6), *Trichometasphaeria* Munk (7), *Massarina* Sacc. (2), *Didymosphaeria* Fck. (2) and *Trematosphaeria* Fck. (10).

Keys are given for each genus. Each species is well annotated and given a full discussion. Synonymy is limited to those binomials of which material has been examined. Host, distribution, exsiccati, type specimens and collections studied are cited for each species.

As Holm himself points out, this is a difficult, interrelated group and his conclusions are based upon a limited number of species, i.e. those found in northern Europe. Consequently the delimitations of genera and species are in some instances somewhat arbitrary or vague. He attempts to make his genera coincide with phylogenetic groups or series. These groups are based largely upon the characters of the ascocarp, particularly those of the wall. Within these taxa, he recognizes series of development based largely upon increasing complexity of spore septation, and attempts to illustrate the sequence within these different series. This attempt to correlate his "feeling" for phylogenetic groups with generic taxa is a commendable one, but results in genera with very vague characterization, and difficult of circumscription by other workers. It seems to the reviewer that there is a tendency, not only by Holm but by others, to place too much emphasis upon wall characters, which, after all are vegetative ones and susceptible to a good deal of variation.

The general term ascocarp is used for the fruiting body of the Pleosporaceae, rather than the debatable one of perithecium or the improper one of pseudothecium. A new term scleroplechtenchyma is used for the type of wall tissue found in *Leptosphaeria doliolum*, i.e. composed of rounded cells with thick walls, which remain hyaline for some time.

This is a careful, scholarly monograph and should aid greatly in the determination of the species of this region and should furthermore stimulate the thinking as regards the taxonomic arrangements of this group, which is at present in a condition of great flux.—L. E. WEHMEYER.

TRAITE DE MICROSCOPIE, INSTRUMENTS ET TECHNIQUES, by A. Polycard, M. Bessis and M. Locquin. vi + 608 pp., 178 figs. Masson & Co., Paris VIe. 1956. Price, unbound 4500 fr. (about $13.00); bound 5200 fr. (about $15.00).

This beautifully written book (in French) supplies a real need in the field of microscopy. The presentation is basic, beginning with a

consideration of microscopes, their mechanics and optics. The topics considered include the optical (photonic) microscope, the phase contrast and darkfield microscopes, the interferometer microscope, the ultraviolet microscope, the polarizing microscope, and finally the electron microscope. Appropriate considerations of mechanisms and techniques are rendered with each type, with a detailed consideration of the optimal conditions necessary for their use.

There is an excellent section on photomicrography, and subsequently a detailed consideration of the methods for the preparation of microscopic materials and staining procedures. This book draws together into one place in a simple and highly understandable form much that the student needs in order to become a proficient microscopist. This reviewer feels that it is a book that all beginning graduate students in biology should study at length as a preliminary to extended reading of other books and journals. Since it is simply and directly written, it likewise offers the advantage of allowing the student to help master his French as he becomes oriented in the field of microscopy.—EDWARD D. DELAMATER.

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